Neonatal Radiology

By

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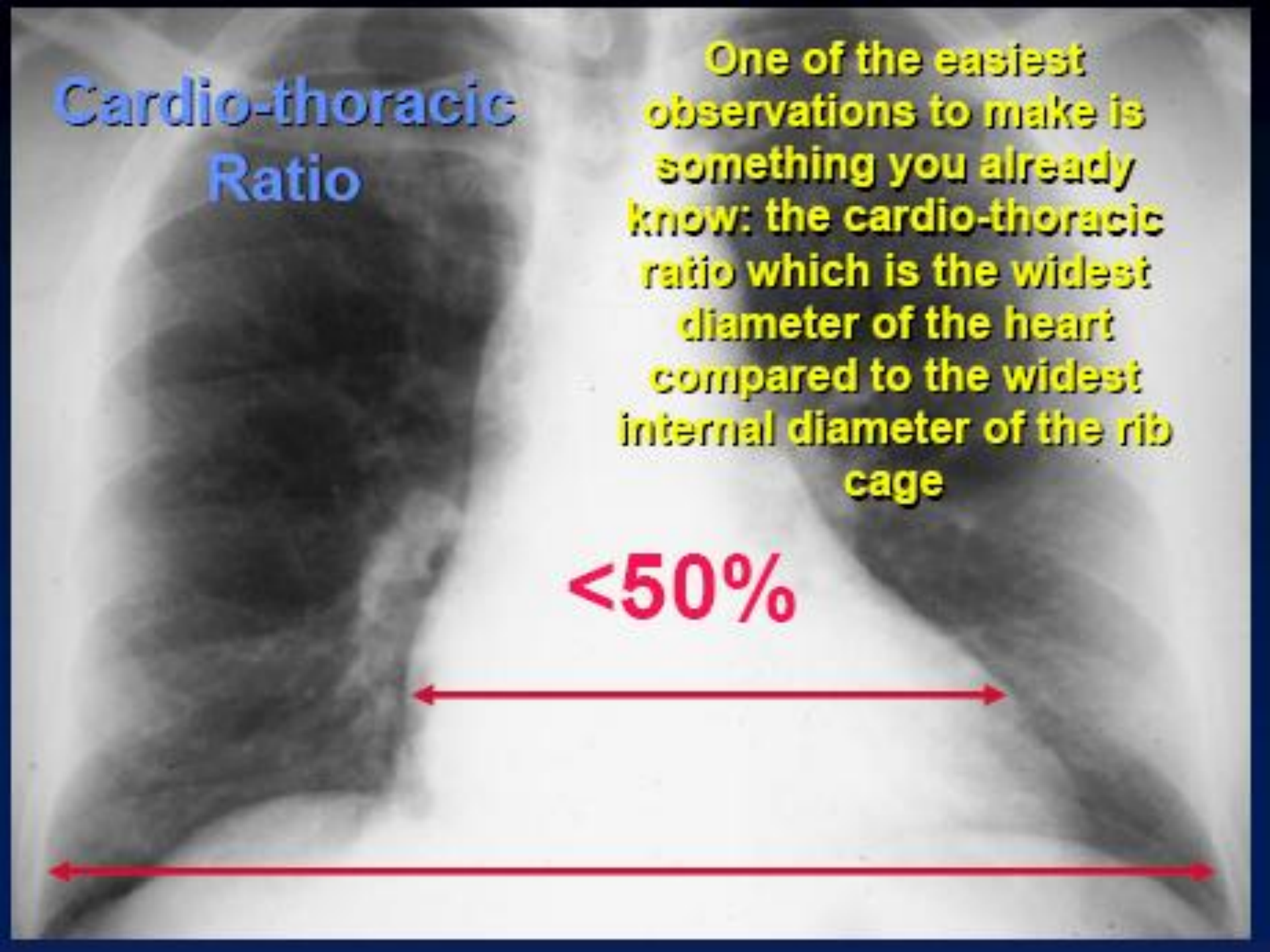
The ABC's of Heart Disease

Cardio-thoracic Ratio

One of the easiest observations to make is something you already know: the cardio-thoracic ratio which is the widest diameter of the heart compared to the widest internal diameter of the rib cage



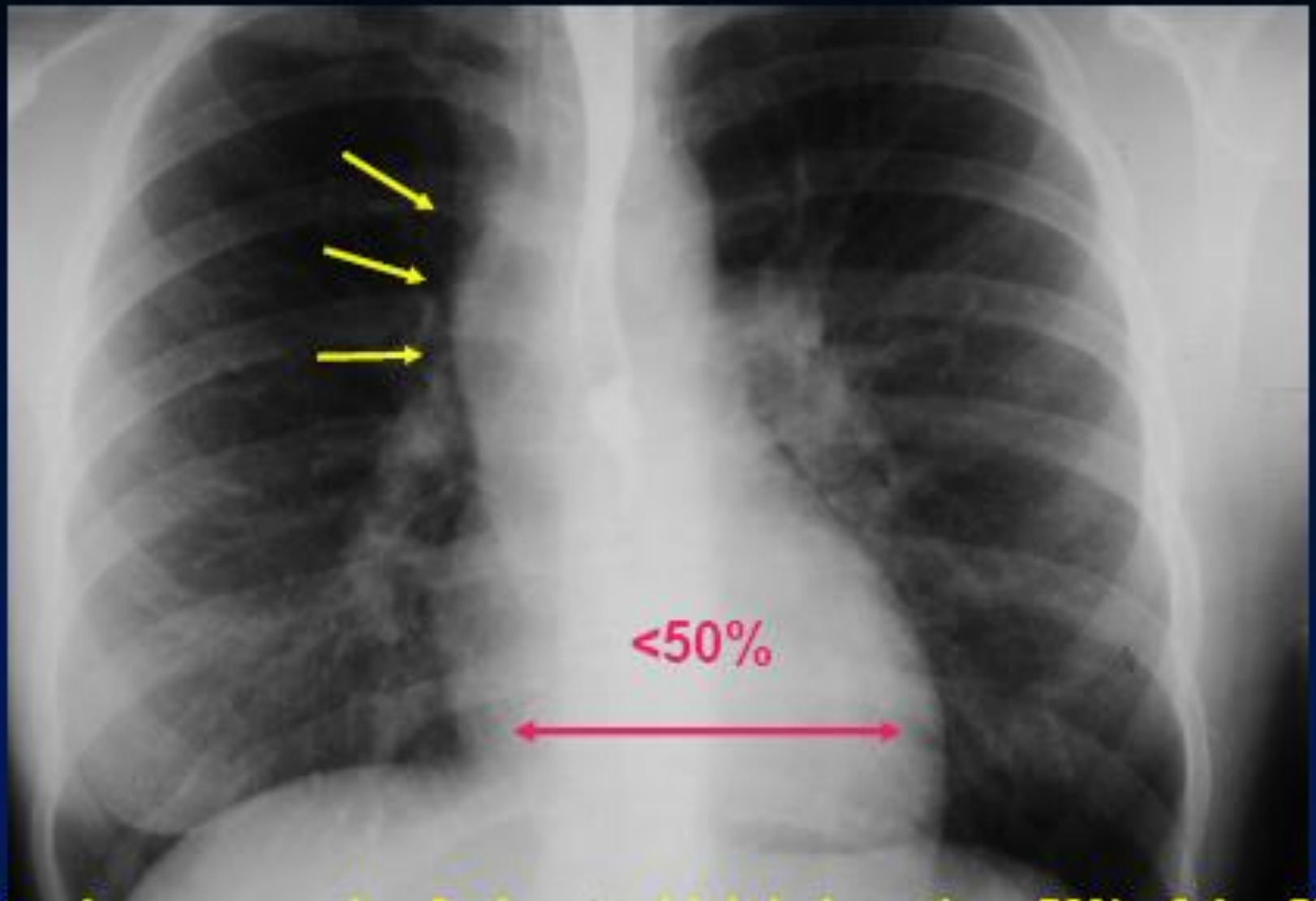
Sometimes, CTR is more than 50%
But Heart is Normal

- Extracardiac causes of cardiac enlargement
  - Portable AP films
  - Obesity
  - Pregnant
  - Ascites
  - Straight back syndrome
  - Pectus excavatum

Here is a heart that is larger than 50% of the cardiothoracic ratio, but it is still a normal heart. This is because there is an extracardiac cause for the apparent cardiomegaly. On the lateral film, the arrows point to the inward displacement of the lower sternum in a pectus excavatum deformity.

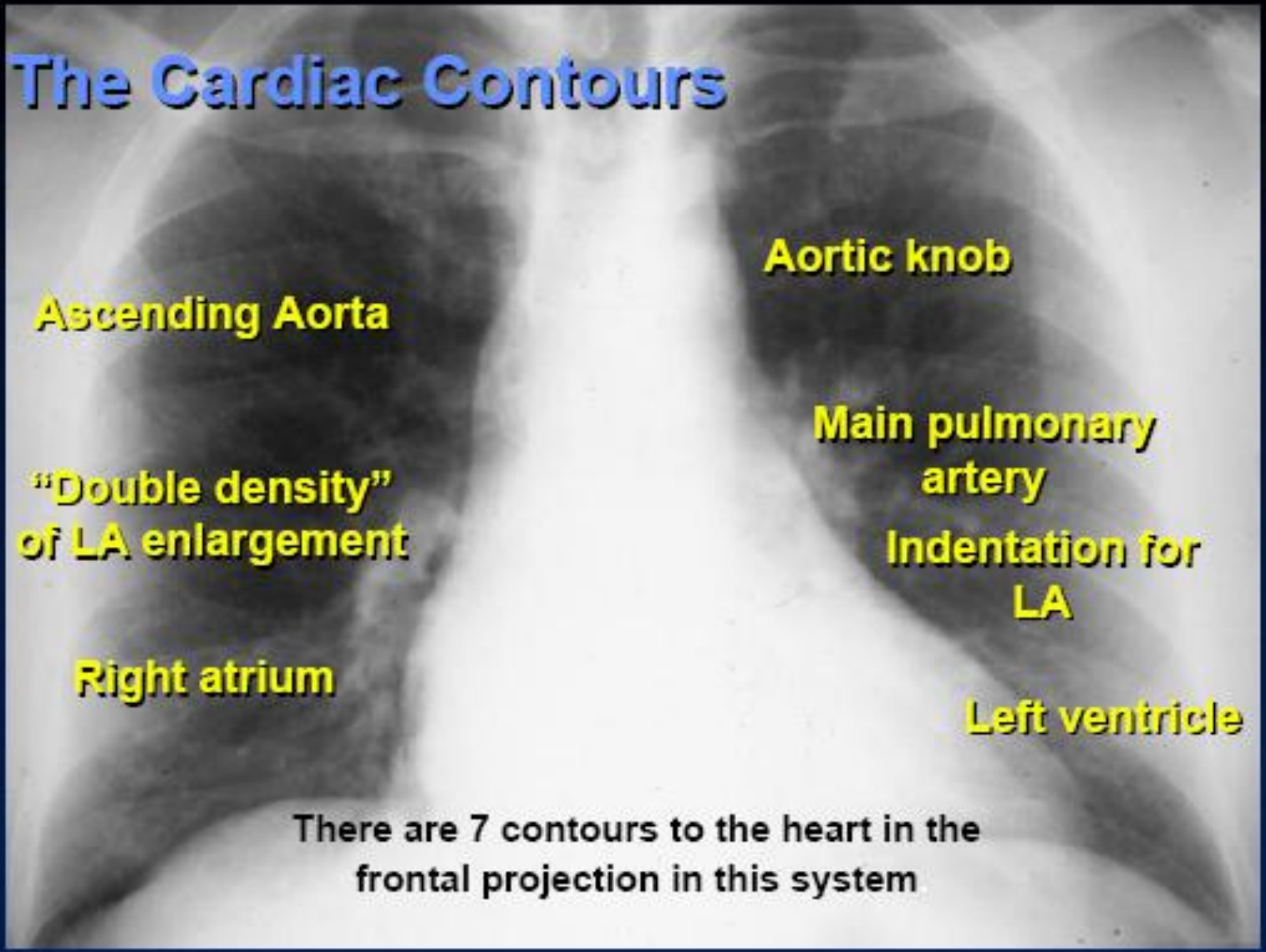
Sometimes, CTR is less than 50%
But Heart is Abnormal

- Obstruction to outflow of the ventricles
  - Ventricular hypertrophy
- Must look at cardiac contours



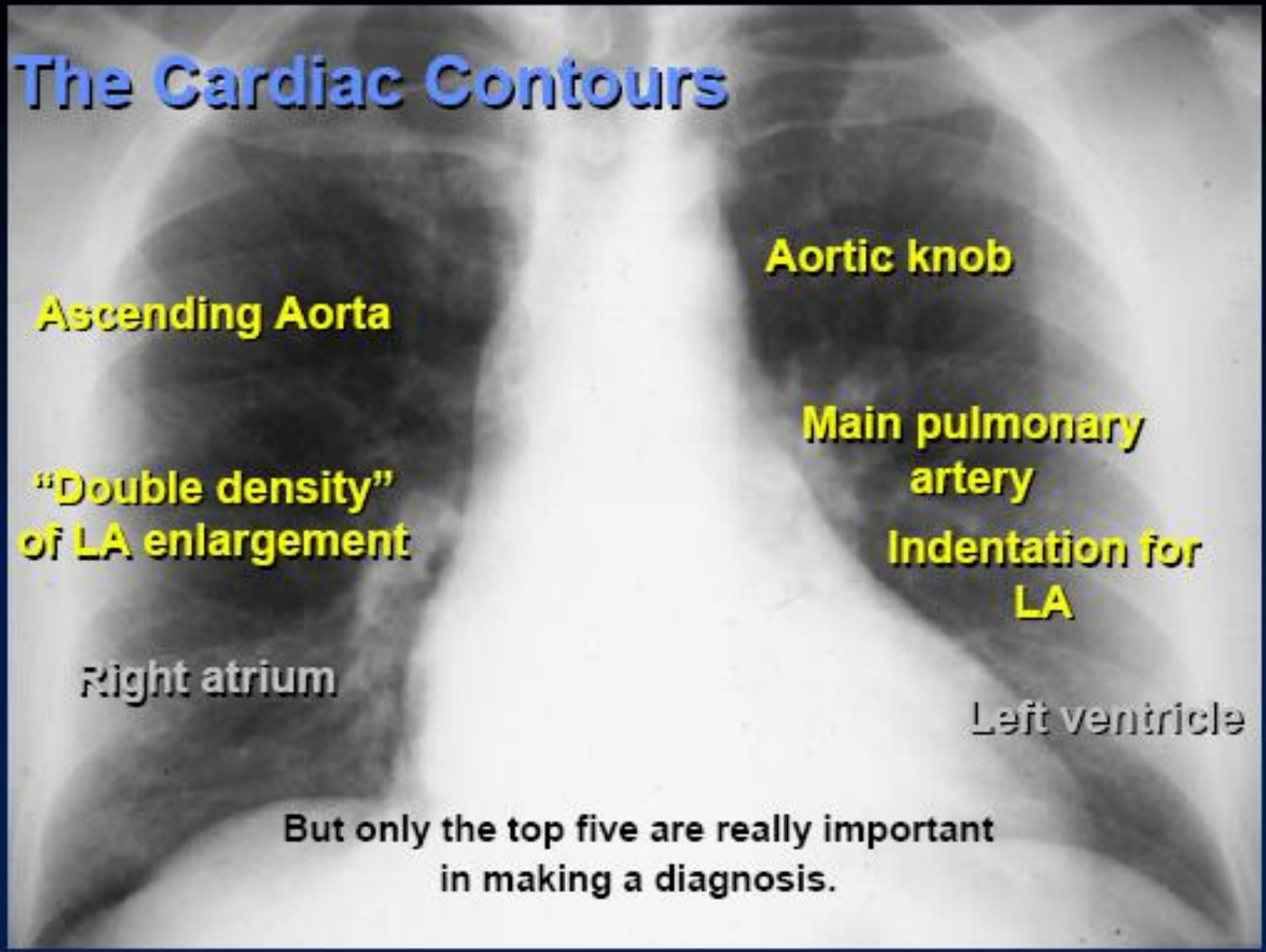
Here is an example of a heart which is less than 50% of the CTR in which the heart is still abnormal. This is recognizable because there is an abnormal contour to the heart (yellow arrows).

The Cardiac Contours

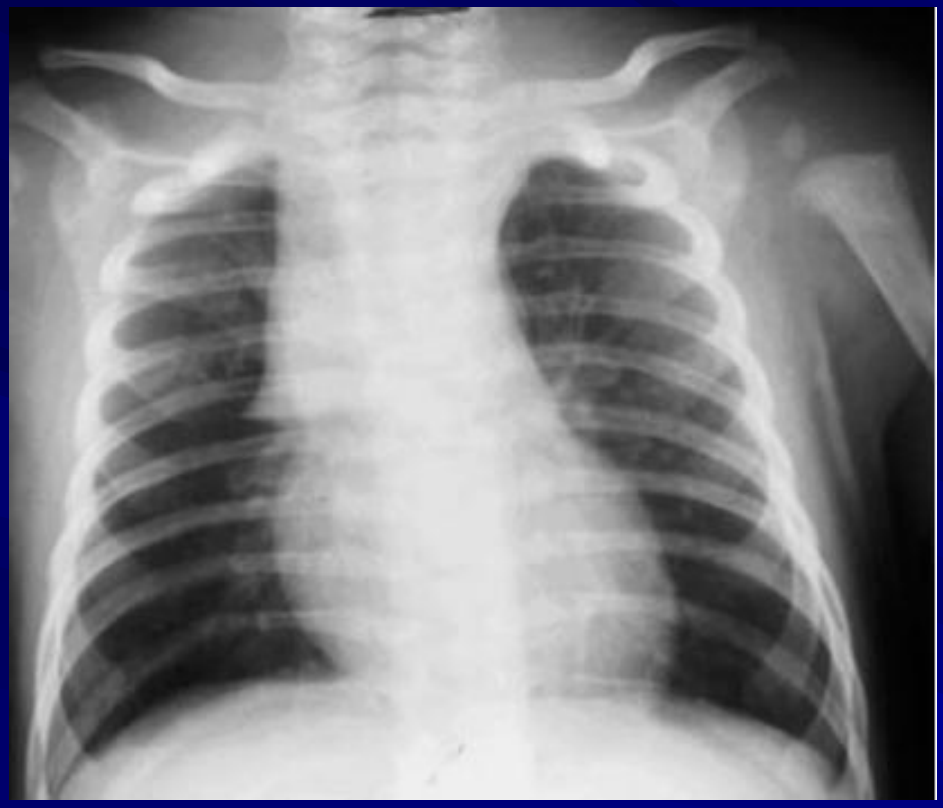


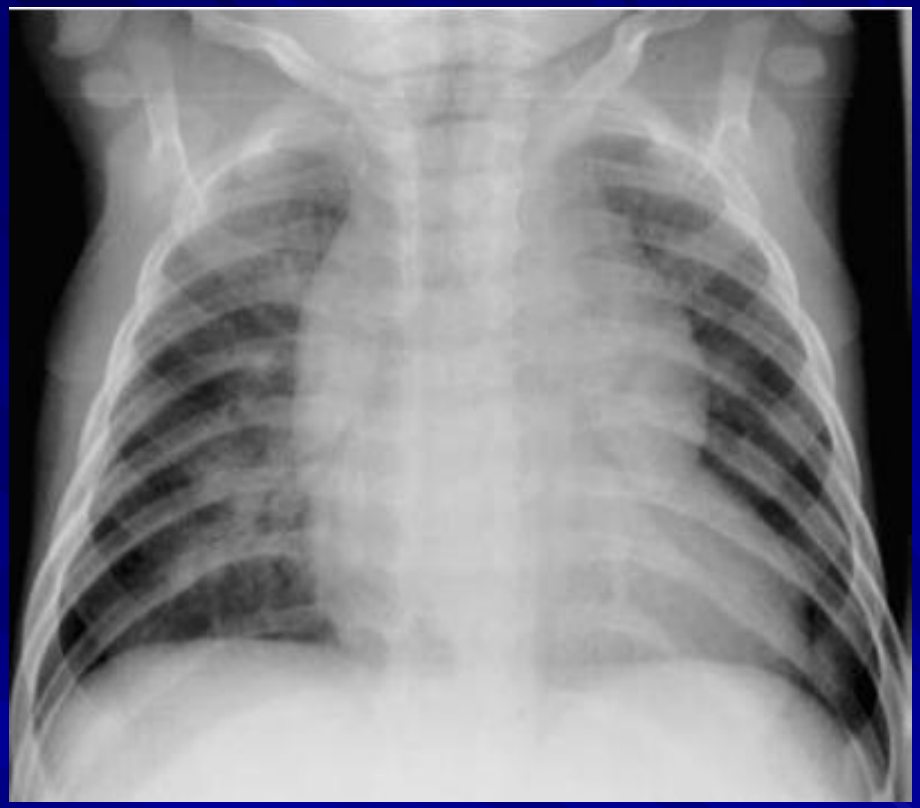
There are 7 contours to the heart in the frontal projection in this system

The Cardiac Contours



But only the top five are really important in making a diagnosis.





Thymus gland. (a) Normal appearance – sail sign. (b) Normal appearance.

Pyloric stenosis. The pylorus is enlarged and the duodenal bulb is indented, consistent with hypertrophy.

Ectopic kidney. The left kidney is located over the sacrum.

Horseshoe kidney. The lower poles are joined. Fusion of the lower poles is more typical than joining at the upper poles.

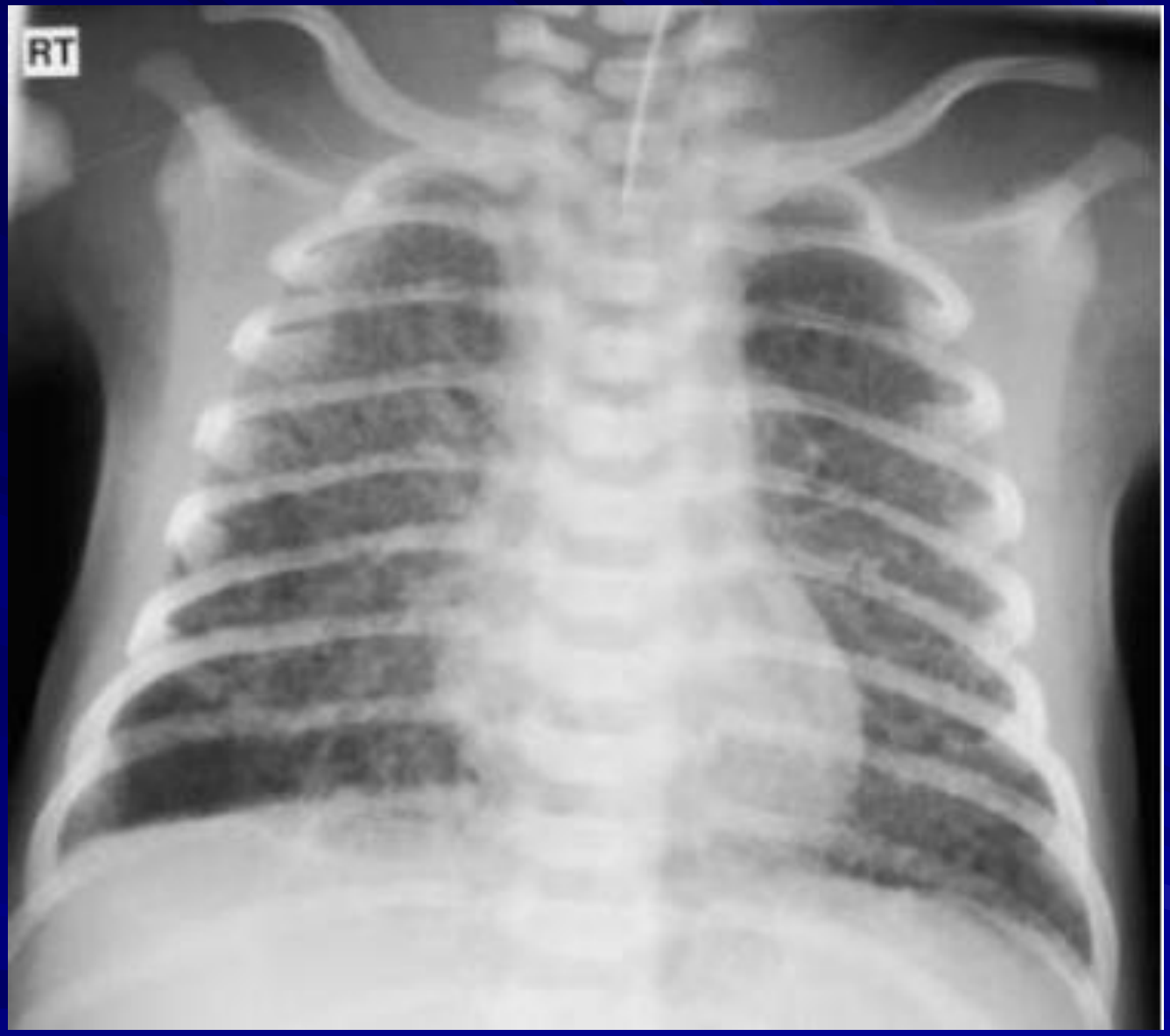
Nephroblastoma. Large right renal mass. Displacement of the right renal collecting system.

Common causes of neonatal respiratory difficulty.

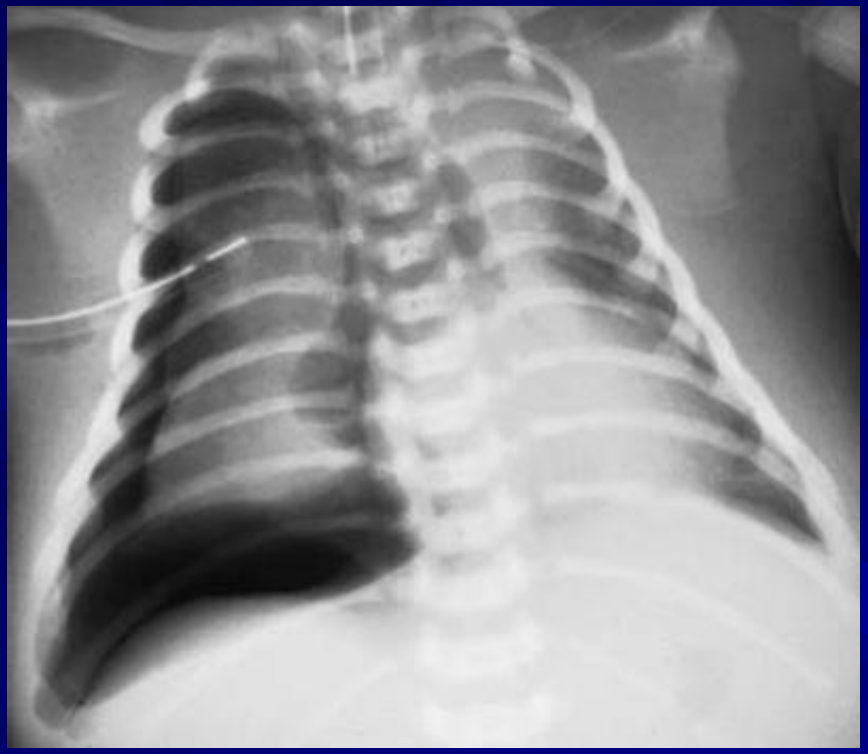
Onset: birth–6 hours	Onset: >6 hours post-delivery	Onset: any time after birth
• Transient tachypnoea • Hyaline membrane disease • Meconium aspiration • Pneumothorax • Persistent pulmonary hypertension • Congenital malformations	• Pneumonia • Congenital heart disease • Underlying metabolic illness	• Upper airway obstruction • Neurological disorders

Transient tachypnoea.

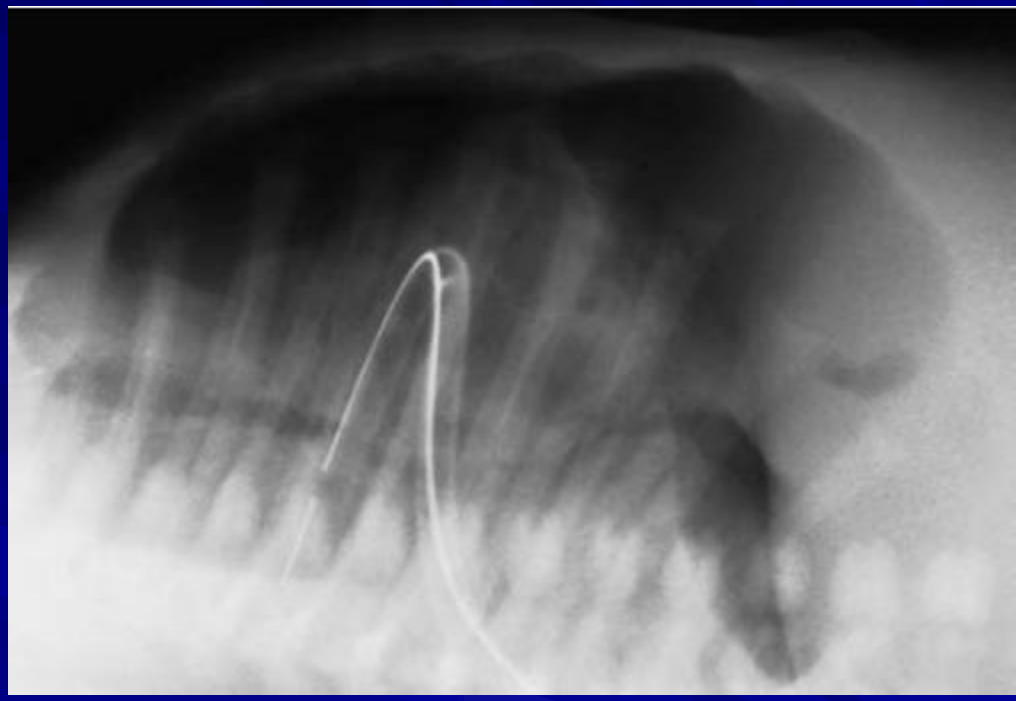
(a) and (b) Hyaline membrane disease.



Meconium aspiration.



Right pneumothorax and chest drain.

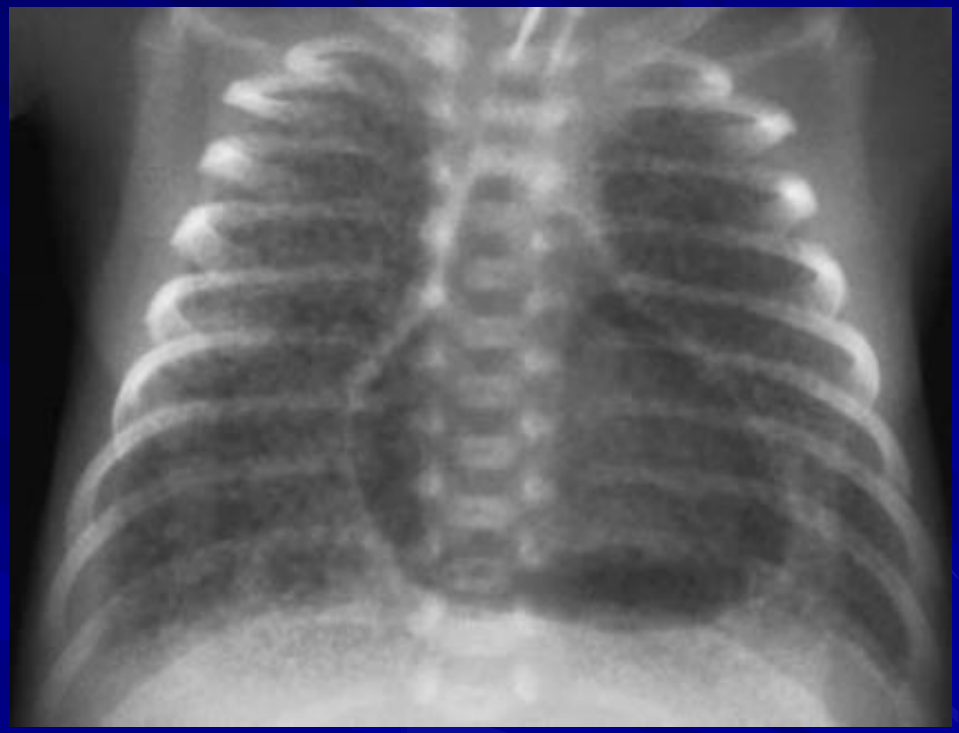


Right pneumothorax and chest drain. Note the retrosternal air visible on the horizontal beam lateral projection.

Pneumothorax with hyaline membrane disease.

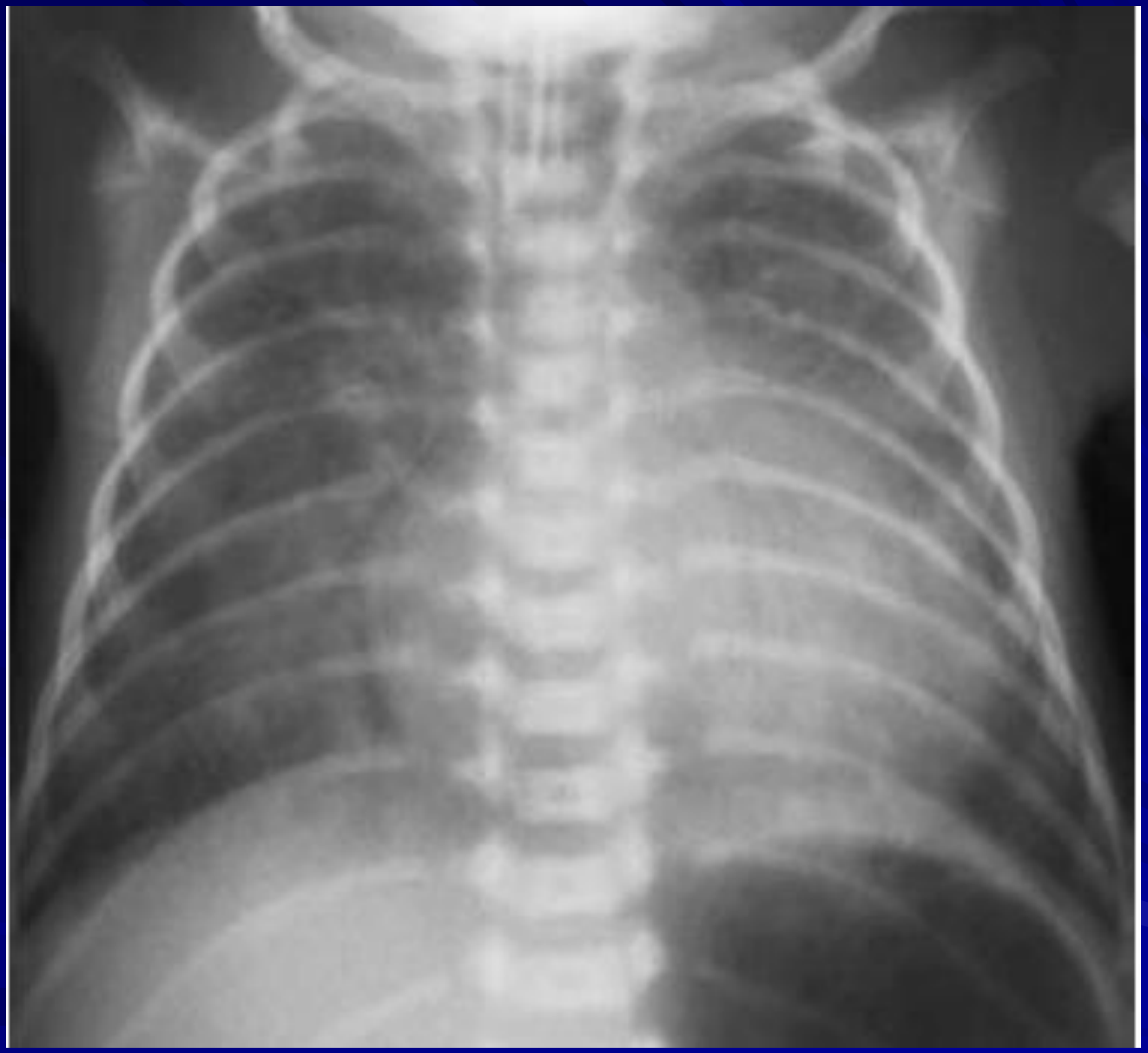
Tension pneumothorax.

Pneumomediastinum.



Pneumopericardium.

Neonatal pneumonia. Patchy consolidation throughout both lung fields.



Several cardiac abnormalities co-existing. Note enlarged heart.

Bowel atresia.

Oesophageal atresia • Affects 1 in 3500 live births

- Failure of the oesophagus to connect to rest of gastrointestinal tract
- Classified into five types – many involve a tracheal fistula
- 50% of neonates with this condition have co-existing abnormalities11
- Aspiration pneumonia a frequent complication
- An antero-posterior radiograph of the chest and upper abdomen following insertion of a radio-opaque tube may be required to identify site of atresia. In a complete atresia the tip of the tube will be seen to lie in the oesophagus and no gas will be seen in the abdomen. If gas is visible within the abdomen then this suggests a tracheo-oesophageal fistula

Duodenal atresia

- Failure of the duodenum to connect to the distal gastrointestinal tract
- Affects 1 in 6000 live births
- 30% of cases are associated with Down's syndrome2
- An abdominal radiograph will demonstrate a large amount of gas in the stomach and duodenum but no gas in the distal gastrointestinal tract ('double bubble' sign)

Jejunal and ileal atresia

- Commonly a congenital stenosis rather than a complete atresia that generally causes obstruction in later infancy rather than during the neonatal period
- No known associated pathologies or conditions
- Radiographic appearances are typical of small bowel obstruction with dilated loops of small bowel and fluid levels being visible

Anorectal atresia (imperforate anus)

- Congenital lack of continuity between rectum and anus
- An inverted erect lateral projection of the pelvis may occasionally be taken using a horizontal x-ray beam

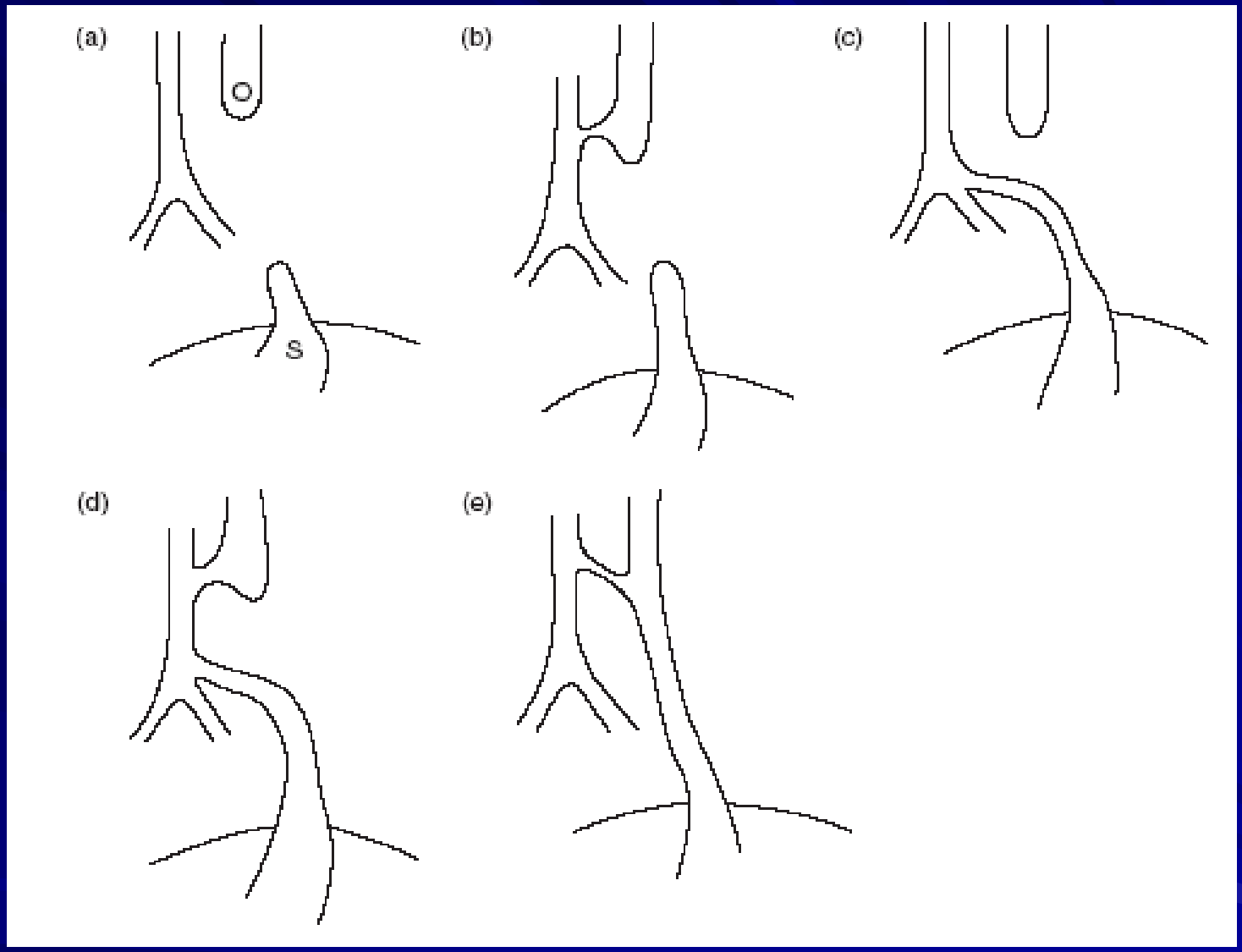


Diagram depicting the five variations of oesophageal atresia. (a) Atresia – no fistula (5–10%). (b) Oesophageal atresia with high fistula only (1%). (c) Oesophageal atresia with low fistula only (80–90%). (d) Oesophageal fistula with low and high fistula (2–3%). (e) H-fistula with no atresia (5–8%). o = oesophagus; s = stomach.

H-type of tracheooesophageal atresia.

Oesophageal atresia. Total absence of gas in the bowel.

Duodenal atresia. Note the ‘double bubble’ sign and the absence of gas in distal gastrointestinal tract.

Plain film of the abdomen on a patient with malrotation.

Contrast examination demonstrating malrotation.

Meconium ileus.

Necrotising enterocolitis.
Bowel distension, pneumatosis intestinalsis and pneumoperitoneum.

Necrotising enterocolitis. Note the significant bowel distension.

Pathologies that may require a lateral chest radiograph.

- Pneumothorax (results in free air in pleural space)
- Plural effusion (results in free fluid in pleural space)
- Abnormality of the thoracic cage
- Abnormality of the diaphragm
- Congenital cardiac abnormality
- Chest mass
- Collapse

Lateral chest radiograph with the patient in the supine decubitus position. There is evidence of a pneumothorax.

A doll is used to demonstrate a lateral abdominal projection with the neonate in the supine decubitus position.

Lateral abdominal projection with the patient in the supine position. Note the free interperitoneal air (triangle sign).

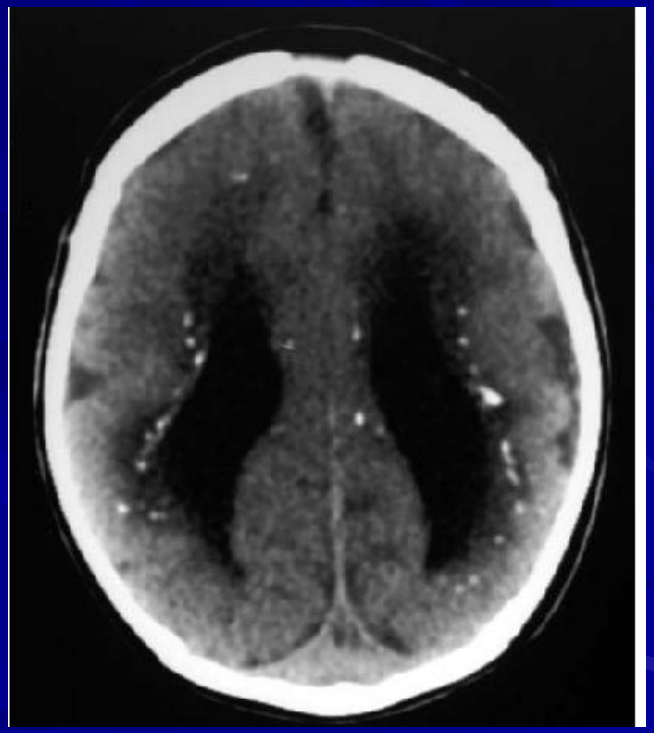
A doll is used to demonstrate positioning for an inverted lateral rectum for imperforate anus.

Horizontal beam lateral rectum for imperforate anus. Note the lead shot to indicate the anus.

Sprengel's deformity. Note the high lying position of the scapula.

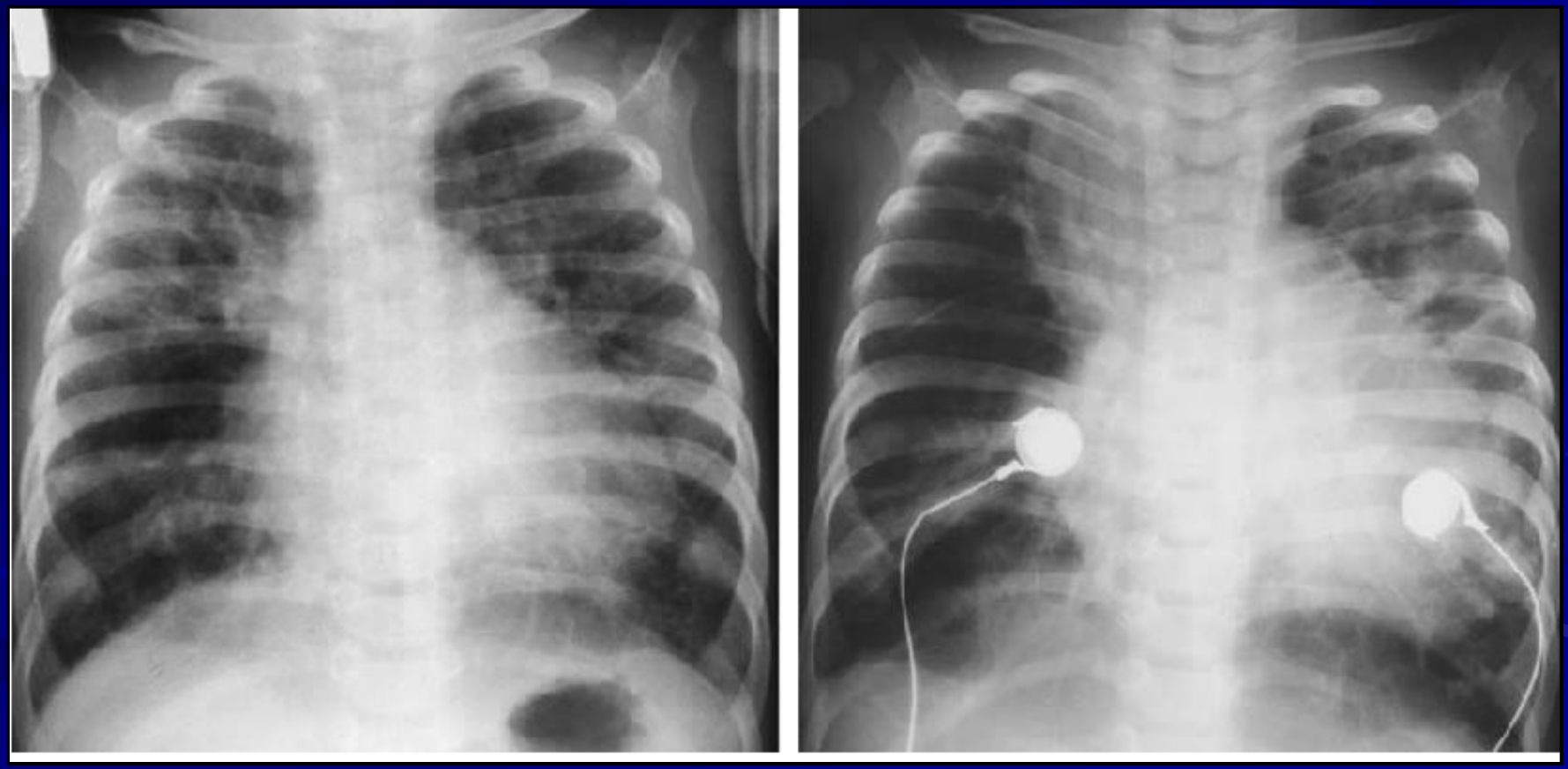
Imaging recommendations in Neurological Disorders

- **CT**
  - **Initial method**
- **MRI**
  - If more details or CT inconclusive
  - Relative long scanning time.
  - Most cases need anesthesia and sedation.
  - More expensive.
  - Sensitive to motion and respiratory artifacts

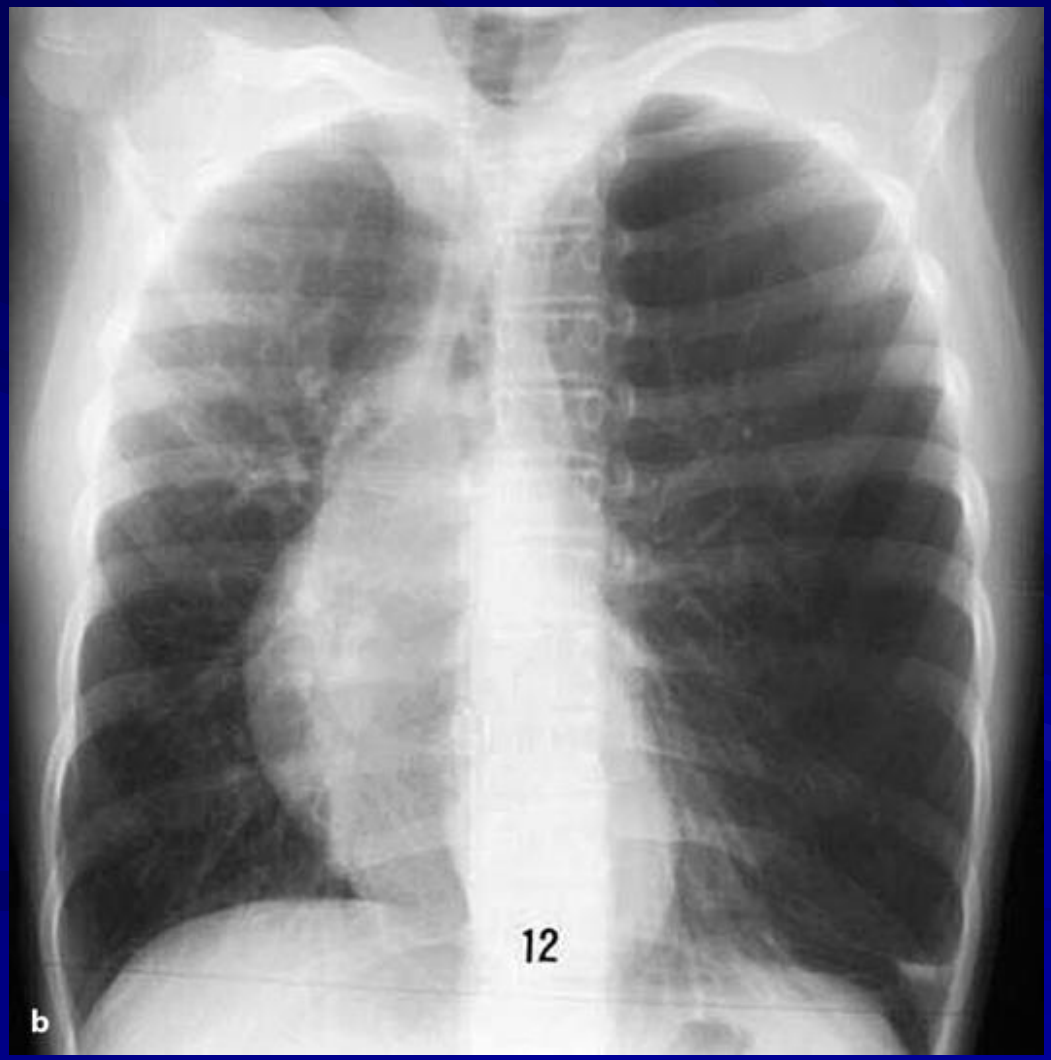


abnormalities

Broncho pulmonary dysplasia



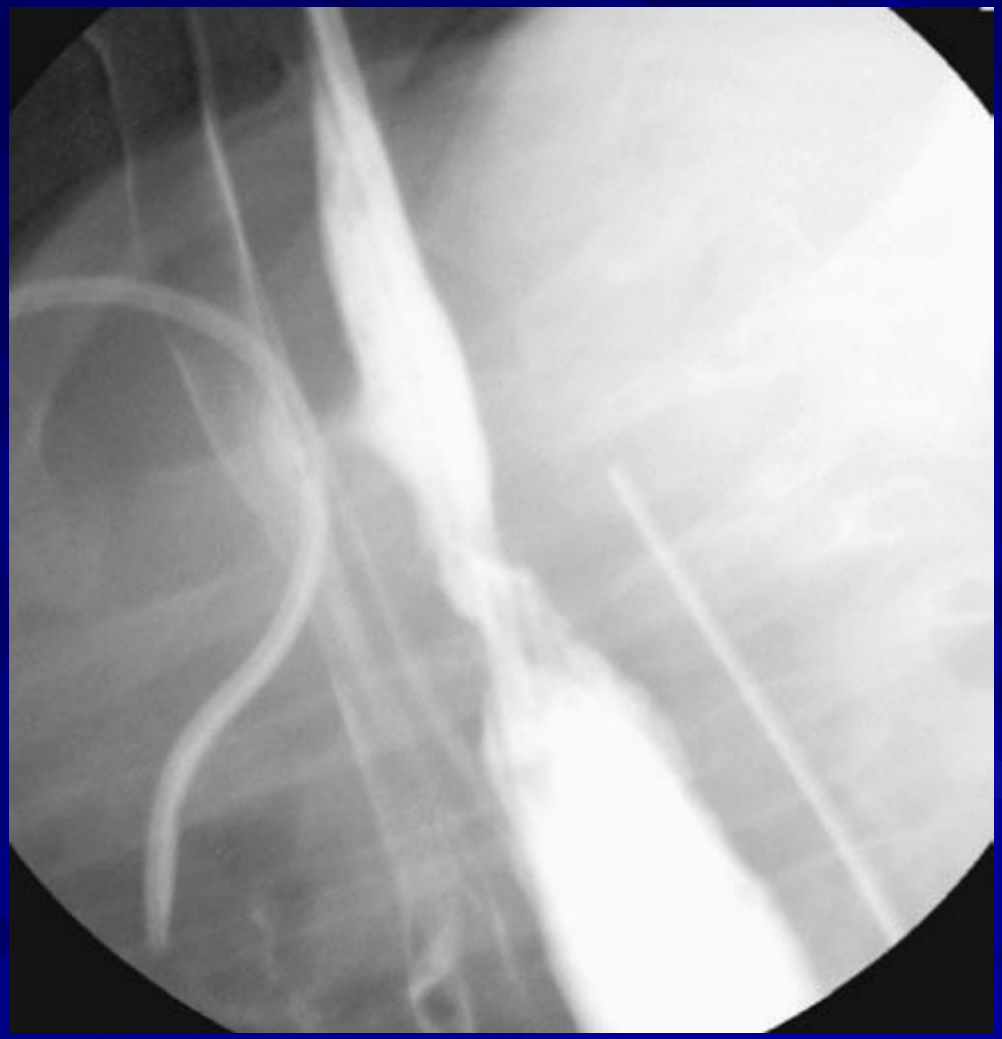
Cogenital lobar emphysema



Perforated viscus

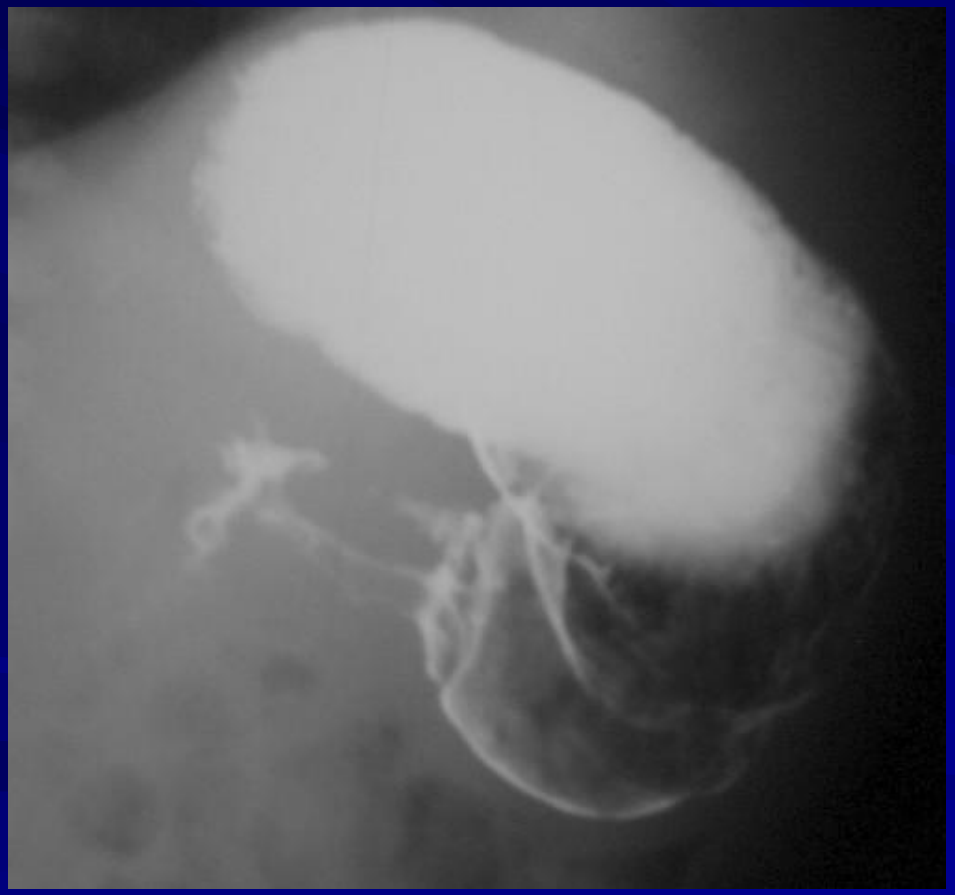
Lower Intestinal obstruction

Contrast swallow



TOF

CHIPS



Advantages of cranial ultrasonography

Major advantages of CUS are the following:

- It can be performed bedside, with little disturbance to the infant, manipulation of the infant is hardly necessary.
- It can be initiated at a very early stage, even immediately after birth.

Cranial ultrasound procedure performed in a premature infant in its incubator

Cranial Ultrasonography: Advantages and Aims

- It is safe; (safety guidelines are provided by the British Medical Ultrasound Society www.bmus.org and the American Institute of Ultrasound in Medicine www.aium.com) (British Medical Ultrasound Society 2006, American Institute of Ultrasound in Medicine 2006).
- It can be repeated as often as necessary, and thereby enables visualisation of ongoing brain maturation and the evolution of brain lesions. In addition, it can be used to assess the timing of brain damage.
- It is a reliable tool for detection of most haemorrhagic, cystic, and ischaemic brain lesions as well as calcifications, cerebral infections, and major structural brain anomalies, both in preterm and full-term neonates.
- CUS is relatively inexpensive compared with other neuro-imaging techniques.
- For all these reasons it is an excellent tool for serial brain imaging during the neonatal period (and thereafter until closure of the fontanels).

Aims of neonatal cranial ultrasonography

The aims of neonatal CUS are to assess

- **Brain maturation**
- **The presence of structural brain abnormalities and/or brain injury**
- **The timing of cerebral injury**
- **The neurological prognosis of the infant**

In seriously ill neonates and in neonates with serious cerebral abnormalities, either congenital or acquired, it plays a role in decisions on continuation or withdrawal of intensive treatment. In neonates surviving with cerebral injury, it may help to optimize treatment of the infant and support of the infant and his or her family, both during the neonatal period and thereafter.

Advantages of CUS	Aims of CUS

• Safe
• Bedside- compatible
• Reliable
• Early imaging
• Serial imaging:
  – Brain maturation
  – Evolution of lesions
• Inexpensive
• Suitable for screening
	• Exclude/demonstrate cerebral pathology
	• Assess timing of injury
	• Assess neurological prognosis
	• Help make decisions on continuation of neonatal intensive care
	• Optimise treatment and support

Well-fitting ultrasound probe, positioned onto the anterior fontanel. Arrow indicates the marker on the probe

Ultrasound examination performed in a full-term newborn infant while infant is seated on his mother's lap (arrow indicates marker on probe)

Ultrasound Screening Programme

In neonatal units it is useful to apply general guidelines for CUS examinations and a CUS screening programme. In Table 5.1, an example of a basic screening programme, as applied at our neonatal intensive care unit (NICU), is presented. This screening programme is used for all infants admitted to our unit, who consist mainly of preterm infants, sick full-term neonates, and neonates with congenital malformations. It calls for at least one CUS examination for each infant, regardless of GA, diagnosis, or medical course, and serial CUS examinations for preterm and sick full-term neonates.

This screening programme is based on the following:

- A first CUS examination soon after birth will give information on congenital anomalies of the brain, congenital infections, some metabolic diseases, traumatic brain injury after traumatic delivery, and the antenatal onset of lesions. It can also serve as a baseline and comparison for the next CUS examinations.
- Haemorrhagic lesions usually become visible within hours of the incident.
- Most haemorrhagic lesions in newborn infants develop around birth.
- More than 90% of peri- and intraventricular haemorrhages (P/IVH) develop within the first 3 days of birth.
- Progression of an initial P/IVH usually occurs within 3 to 5 days.

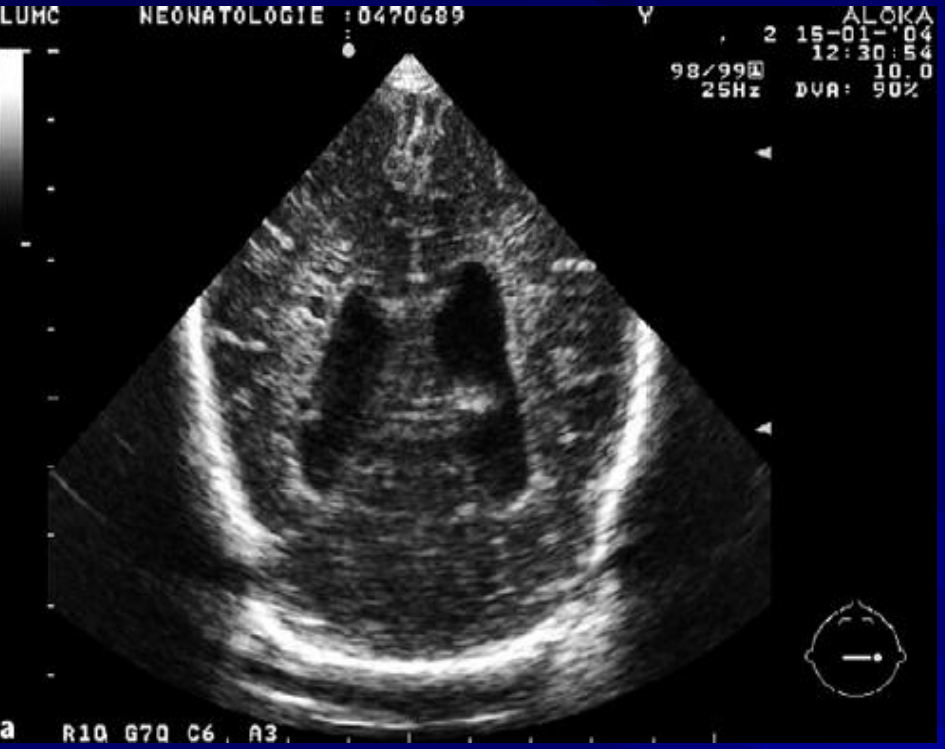
CUS screening programme

NICU and/or <32 weeks GA and/or birth weight <1,500 g	High care and ≥32 weeks GA and ≥1,500 g
<24 h after birth	
On the third day	On the third day
Biweekly until the second week	
Weekly until discharge	Weekly until discharge
Around term[a]	
More frequently in the case of (suspected) abnormalities	More frequently in the case of (suspected) abnormalities

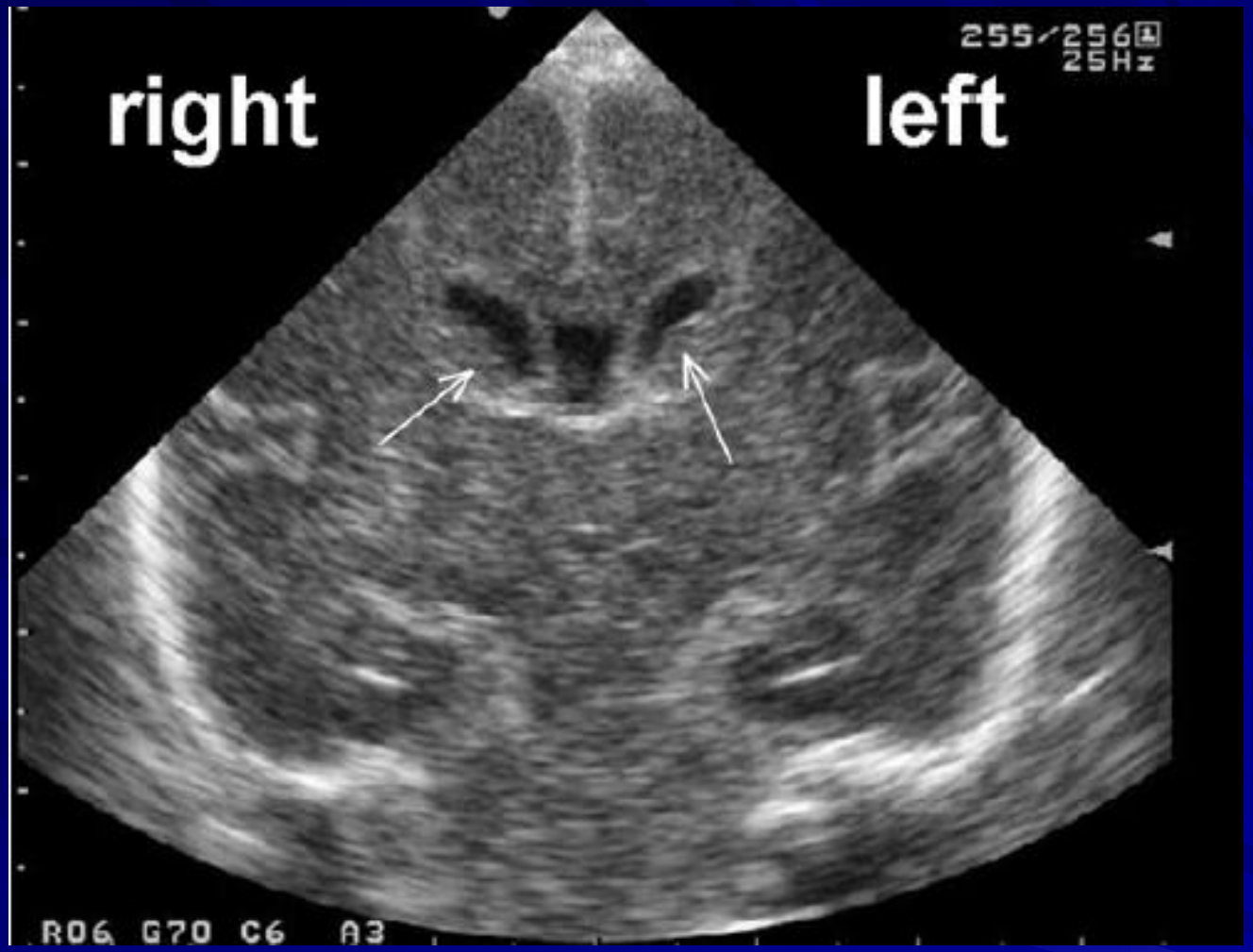
[a]It is recommended that term CUS be performed at the neonatal centre

Indications for Ultrasonography at Term Corrected Age

- Born prematurely, < 32 weeks and/or birth weight < 1,500 g
- Periventricular leukomalacia ≥ stage 2 according to De Vries et al. (1992)
- Periventricular echodensities (flaring) still present at discharge/transfer
- Non-homogeneous periventricular flaring (even if already subsided at discharge/transfer)
- Other lesions of brain parenchyma (such as periventricular haemorrhagic parenchymal infarction, arterial infarction, basal ganglia lesions, brain abcesses, global hypoxic-ischaemic brain damage, etc.)
- P/IVH stage 3 (Volpe 2001b) and/or periventricular haemorrhagic infarction and/or post-haemorrhagic ventricular dilatation, needing treatment
- Meningitis or brain infections

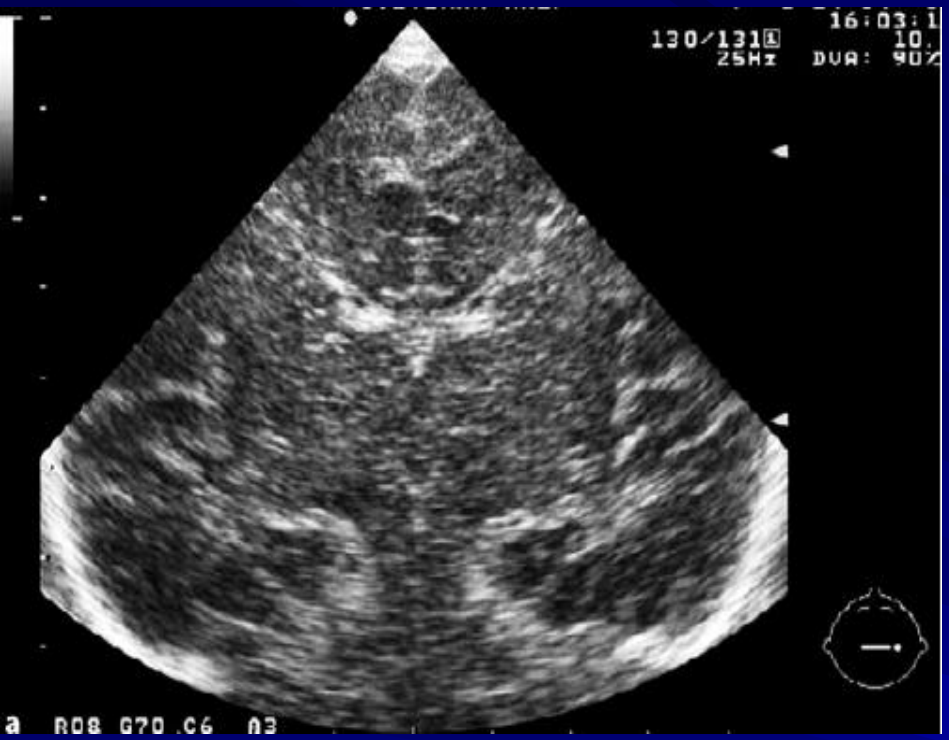


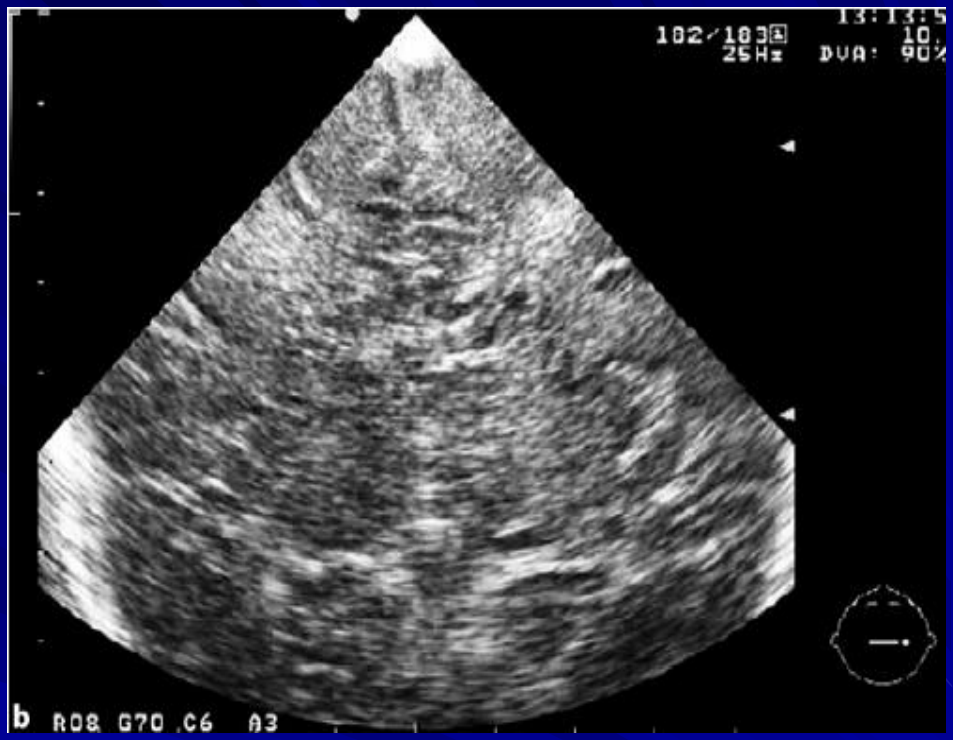
Ultrasound scan in a preterm infant with cystic periventricular leukomalacia, showing cystic lesions and increased echogenicity in the parietal periventricular white matter, seen in two image directions. a Coronal scan at the level of the trigone of the lateral ventricles. b Parasagittal scan through the right lateral ventricle



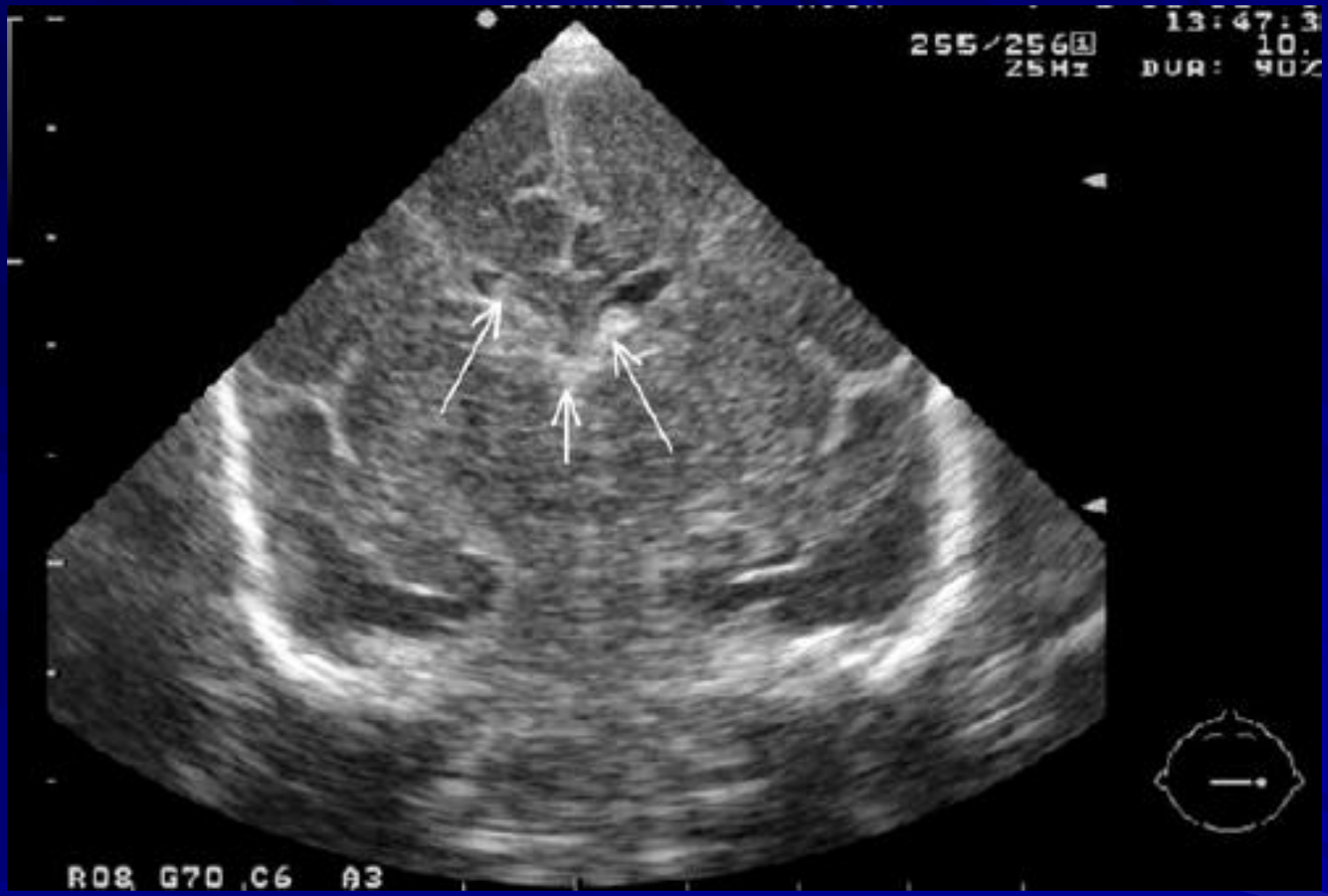
Coronal ultrasound scan in a very preterm infant at the level of the frontal horns of the lateral ventricles. If the marker on the transducer is positioned in the right corner of the anterior fontanel (see Figs. 2.1 and 3.1), the right side of the brain is projected on the left side of the image, and vice versa. Image shows germinal matrix haemorrhages of older duration (arrows)

Transverse view of brain stem showing circle of Willis, using colour Doppler





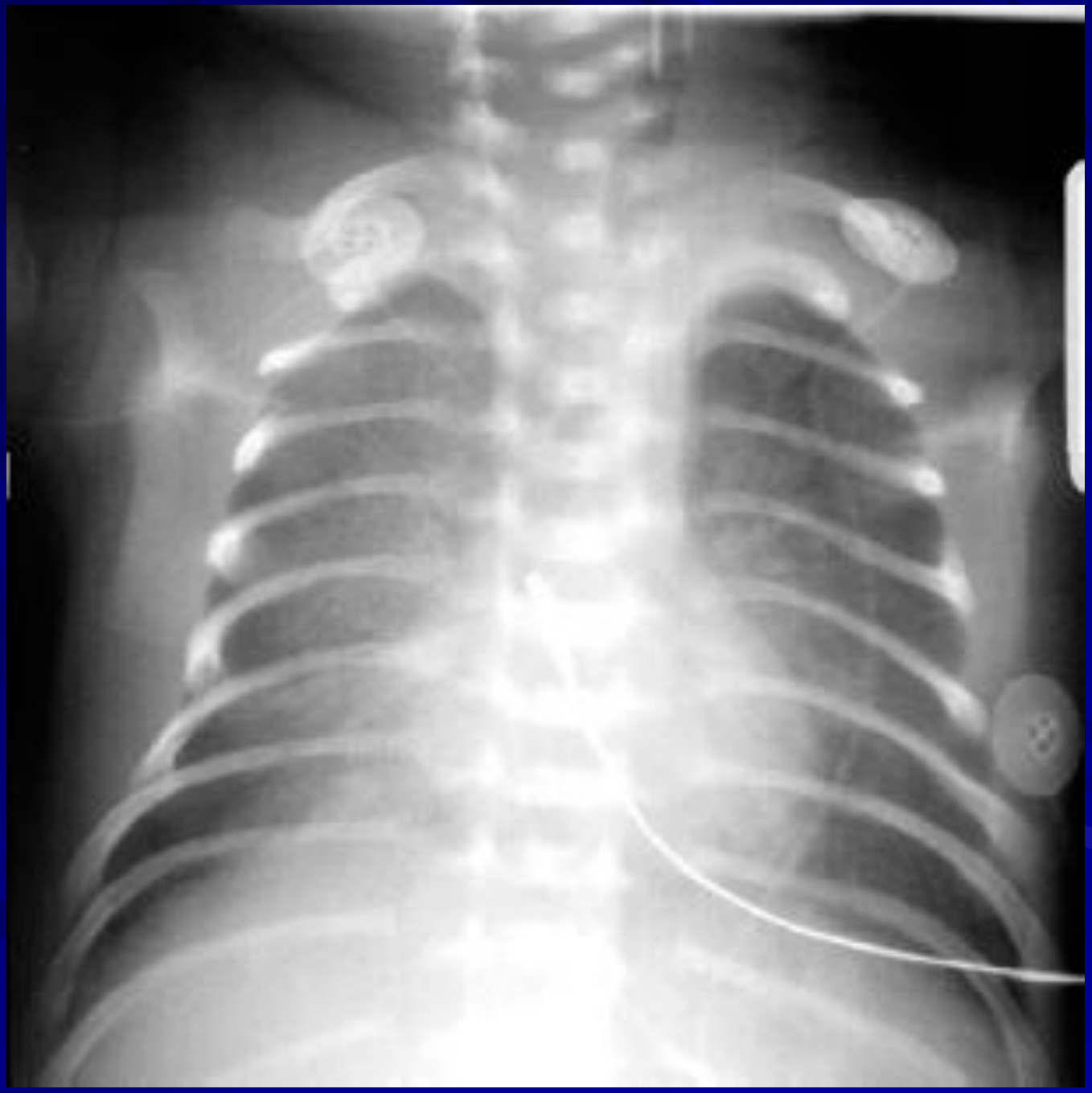
Coronal ultrasound scan at the level of the bodies of the lateral ventricles. a Normal image in a full-term neonate. b Loss of normal architecture and diffusely increased echogenicity in a full-term neonate with severe hypoxic-ischaemic brain damage



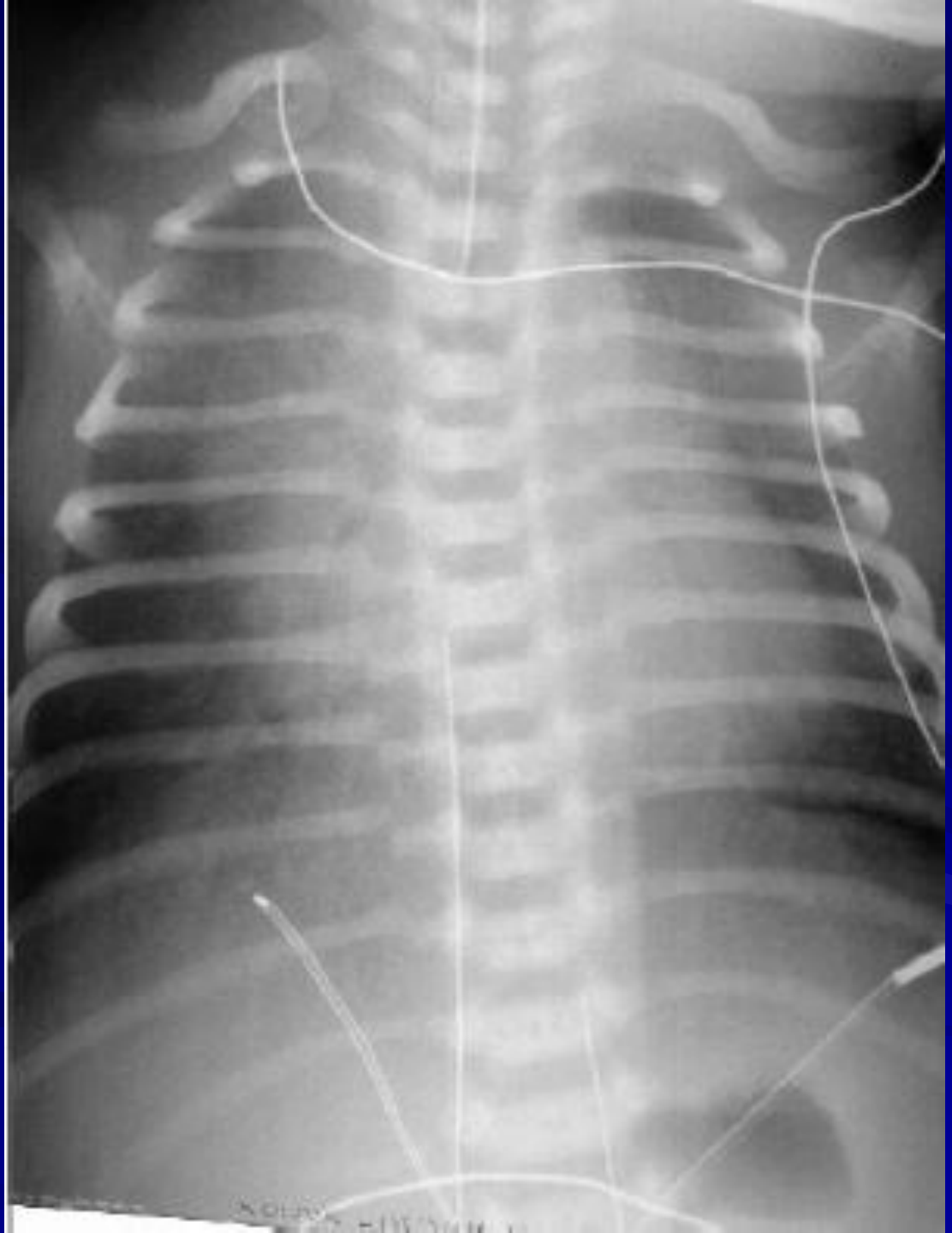
Coronal ultrasound scan at the level of the bodies of the lateral ventricles in a preterm infant (GA 30 weeks), showing bilateral (arrows) with blood clot in the third ventricle (short arrow).

Quize

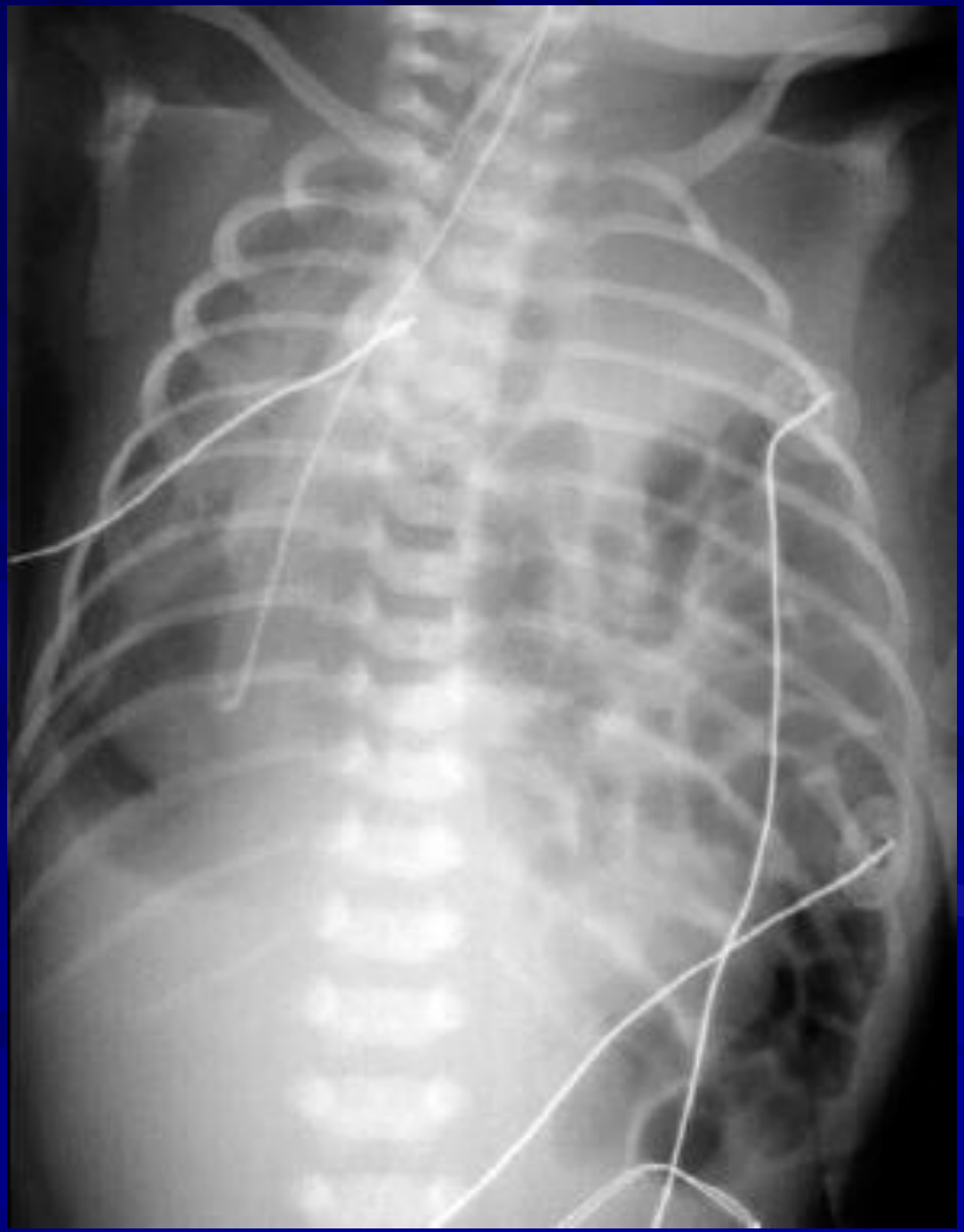
Subtle right pneumothorax.



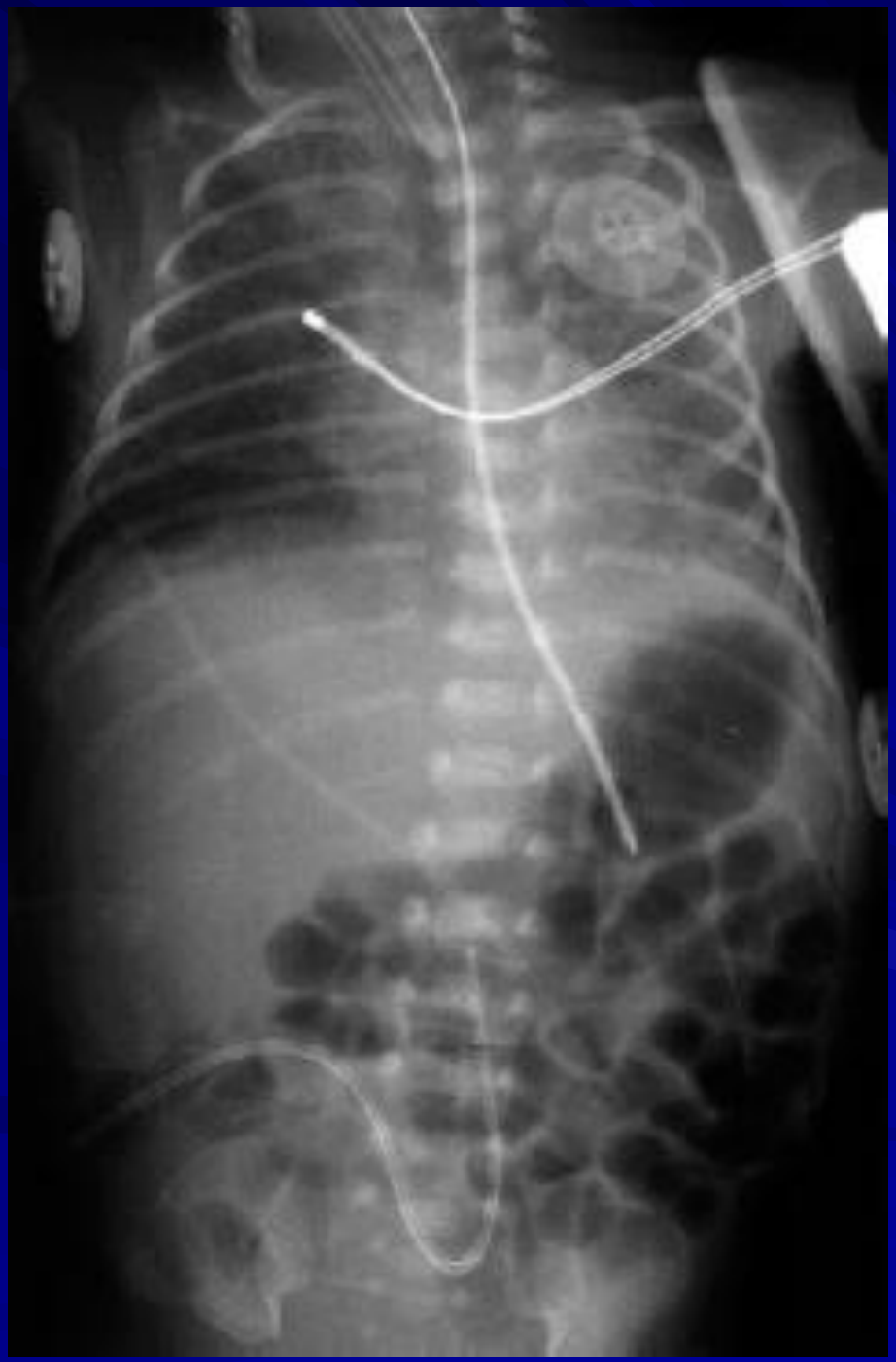
Respiratory distress syndrome. ETT is too high. You must always note the ETT position and reposition it if necessary.



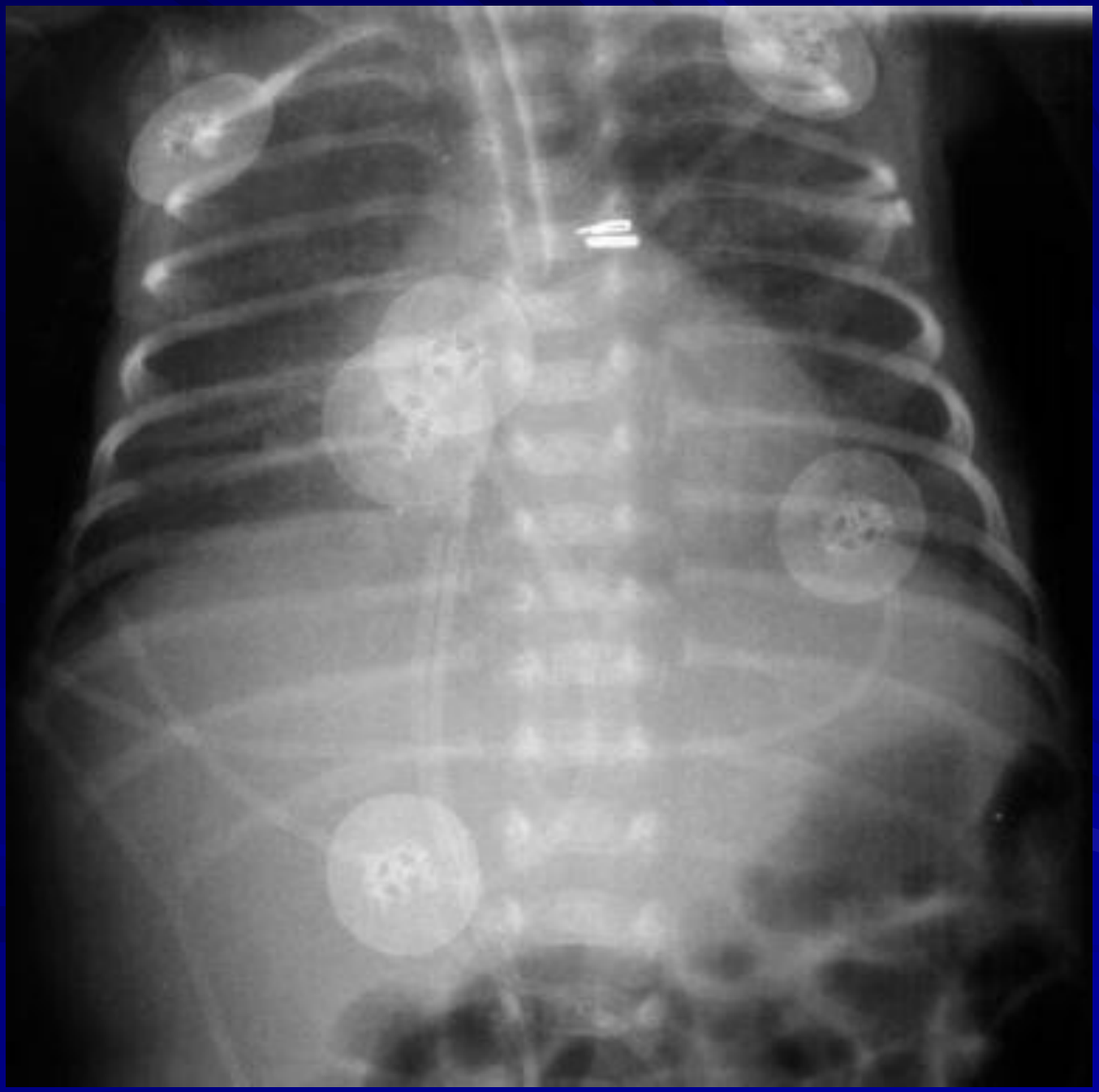
UAC at T11. UVC above diaphragm. How can you distinguish UAC from UVC. You really need to see the umbilicus portion of this radiograph to follow the lines up. Without this information, one can't be certain, but most likely, the line on the patient's left more closely follows the path of the aorta so this is probably the UAC. The line on the patient's right more closely follows the hepatic vein so this is probably the UVC.



Left diaphragmatic hernia. There is also a small right pneumothorax, but this is difficult to see since bowel gas overlies it.

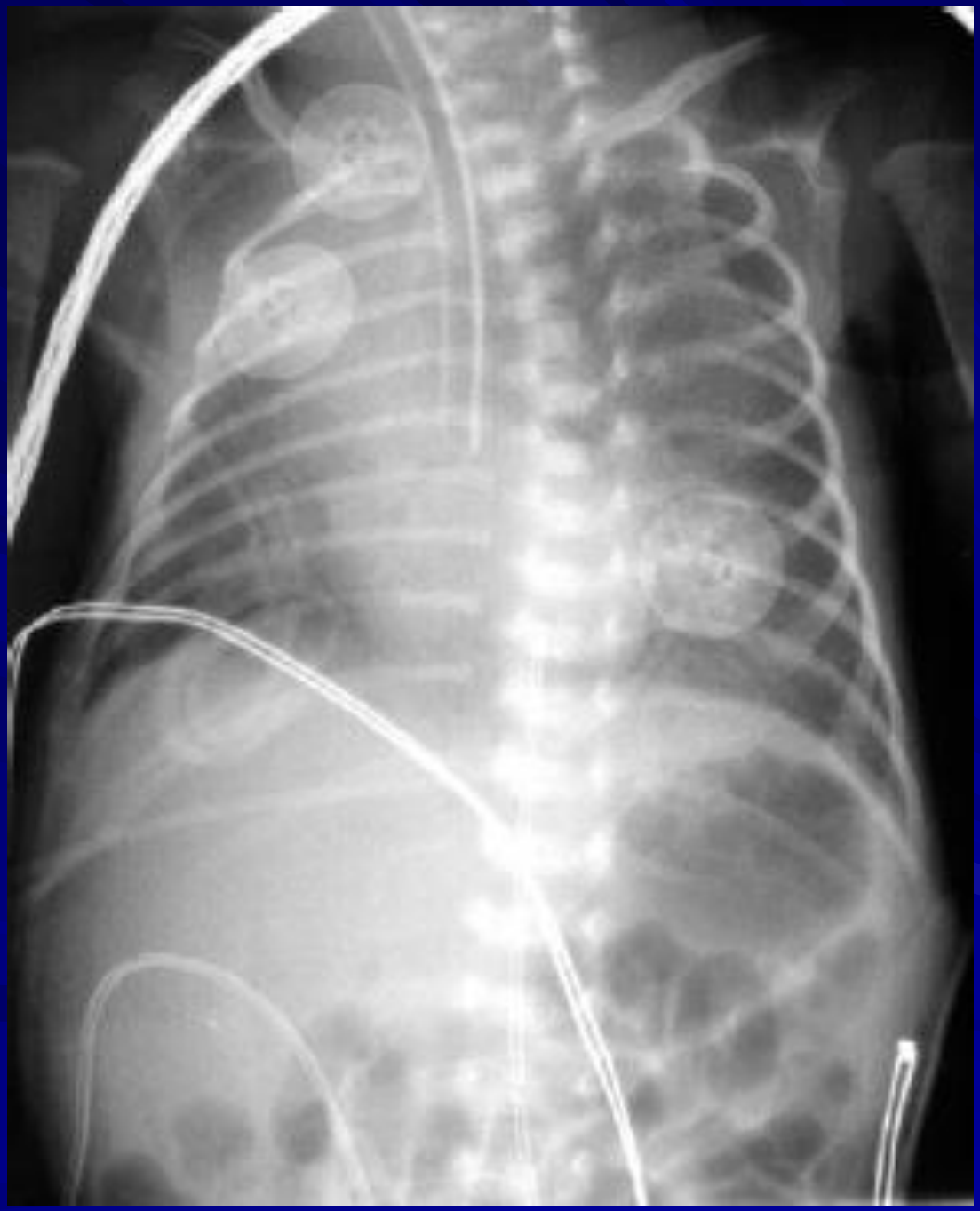


UAC at L2 (too high). Note how the UAC dips down and then up as it enters the umbilical cord into the aorta. This is the hallmark of a UAC and not a UVC.



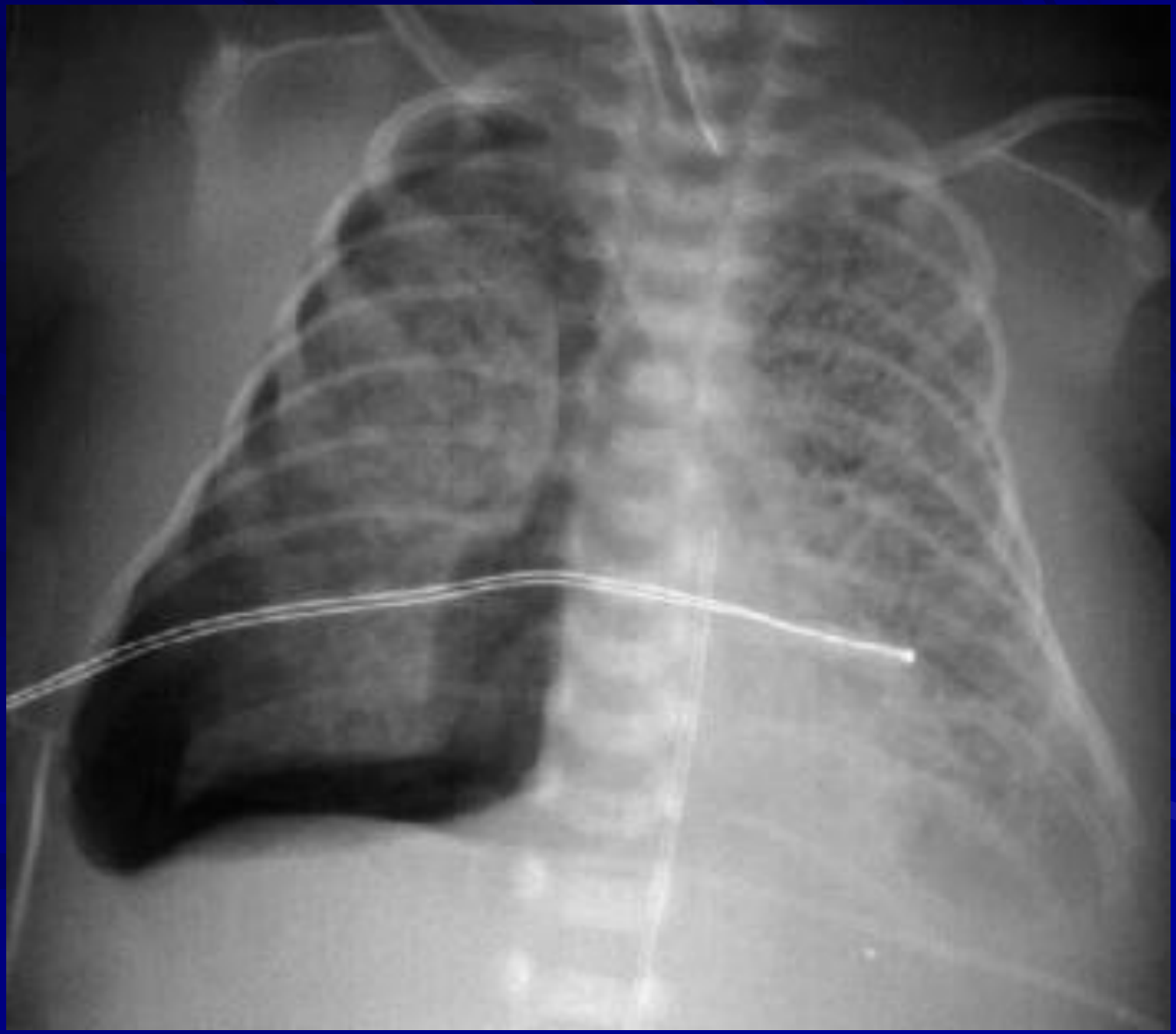
ETT too low. It should be repositioned.

Pneumatosis intestinalis. Note the air visible in the bowel wall. The air dissects the bowel wall giving it a double lined appearance (ie., railroad tracks without the ties). Necrotizing enterocolitis.

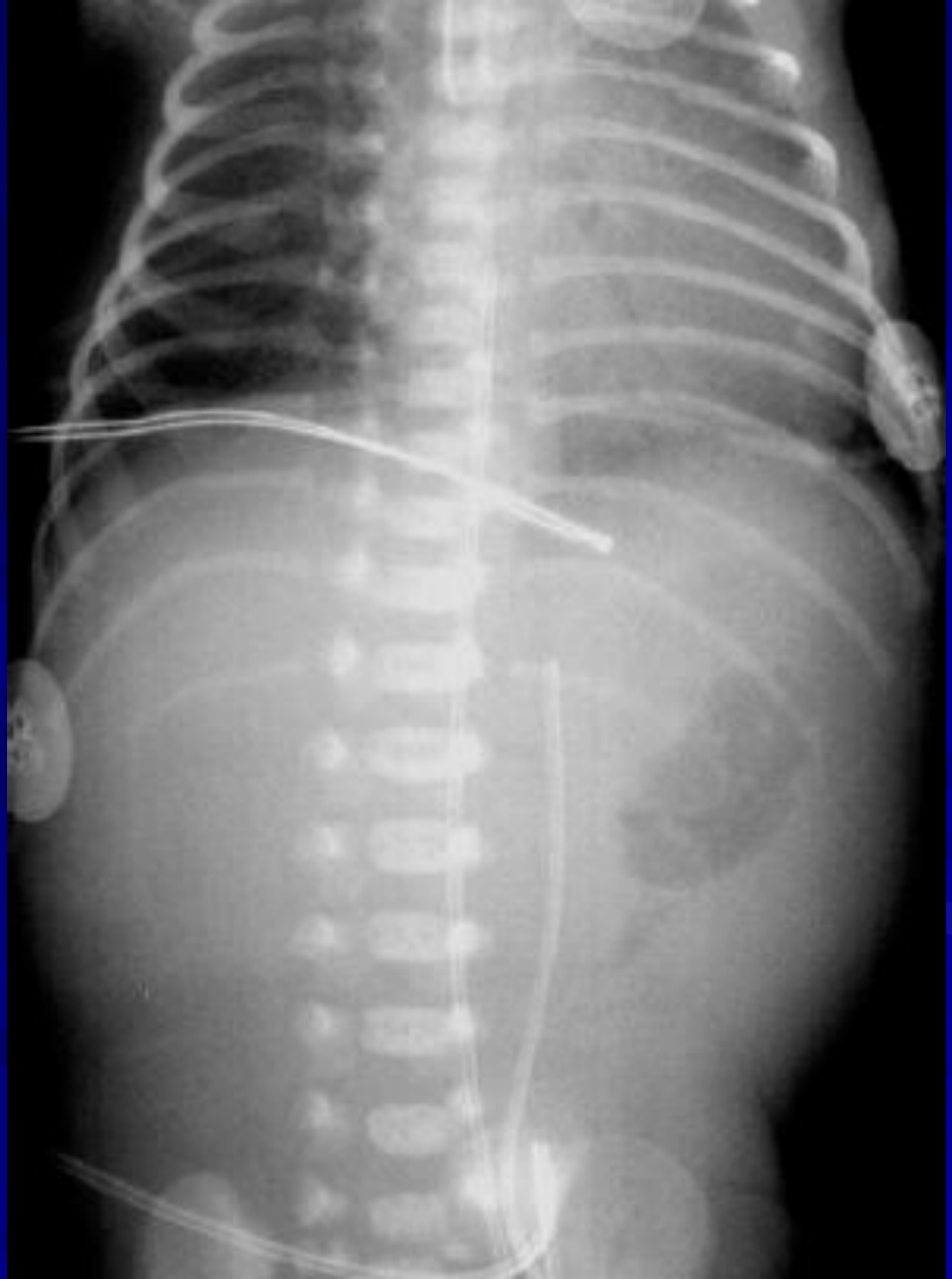


ETT too low. Reposition it. UAC OK at T9.

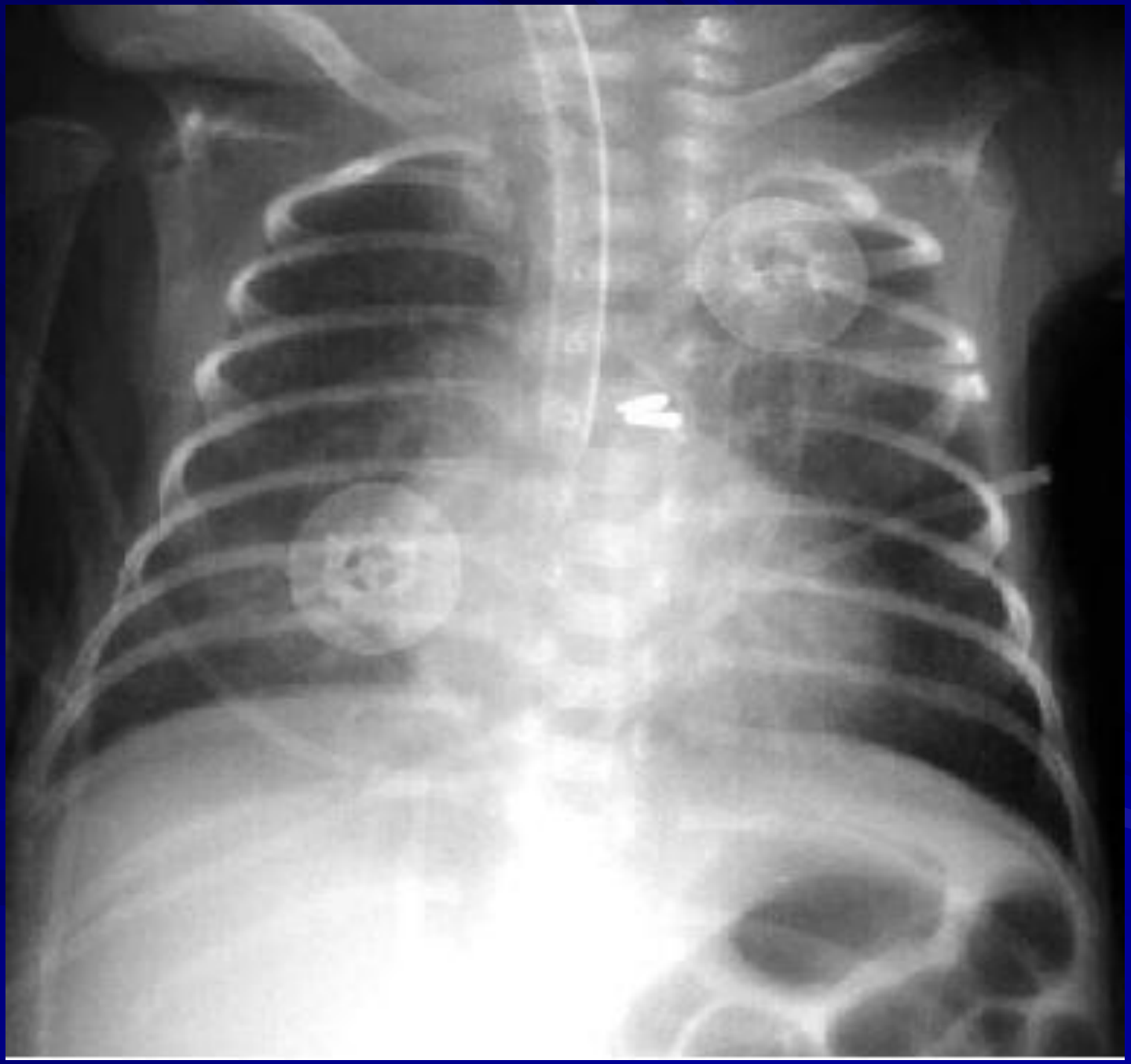
RDS. ETT in satisfactory position, but note that there are two tubes up there. The smaller one is an NG tube that is in the upper esophagus (too high). The UAC is OK at T4. There is some radiocontrast in the lower bowel.



Right pneumothorax. Pulmonary interstitial emphysema. UAC OK at T7.

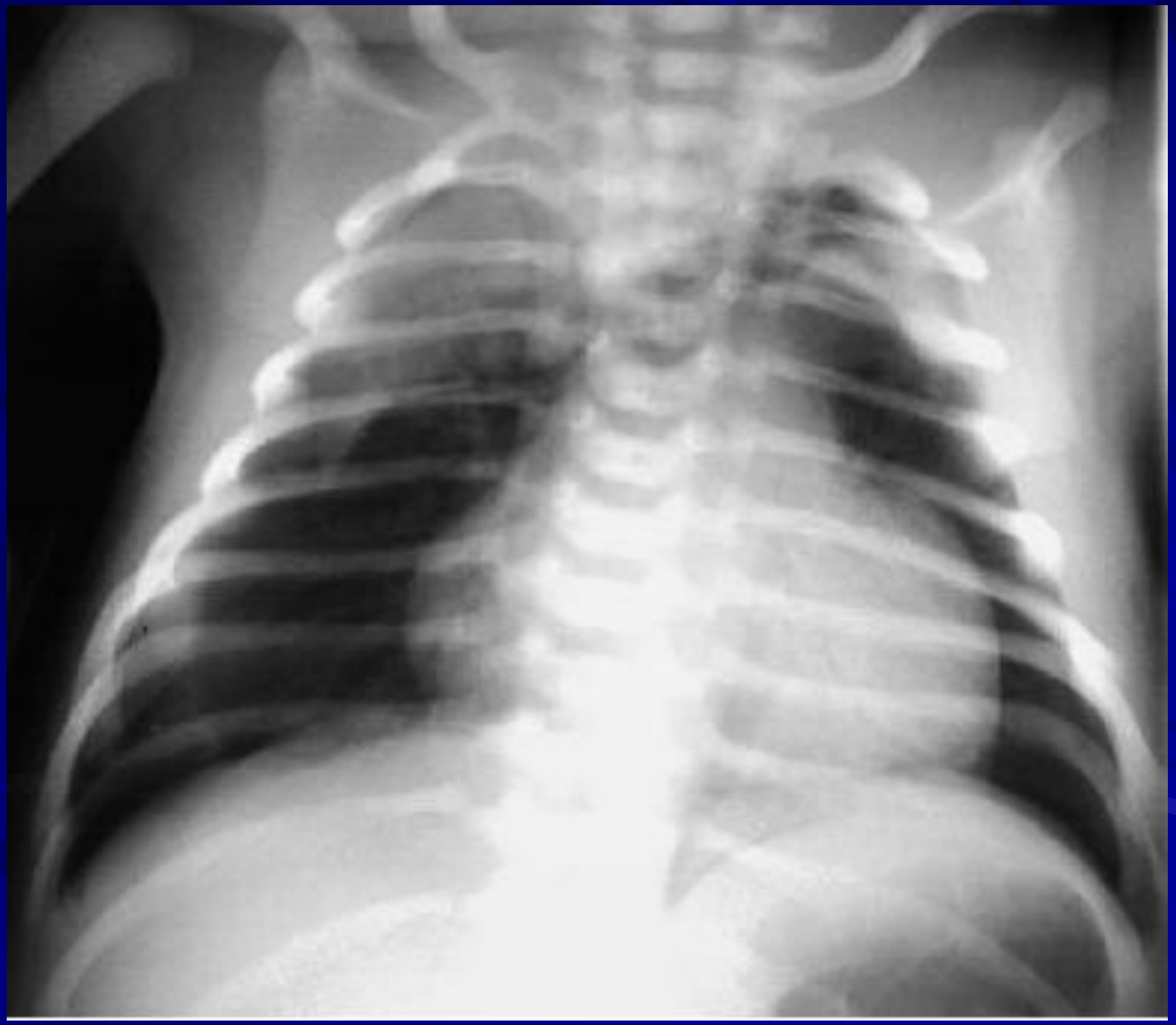


In this case the UVC is on the patient's left and the UAC is on the patient's right. I'm not sure why this is. However, there is significant rotation in the positioning of the radiograph. Note that the UVC goes straight up, while the UAC goes down and then up as it enters the body through the umbilicus.

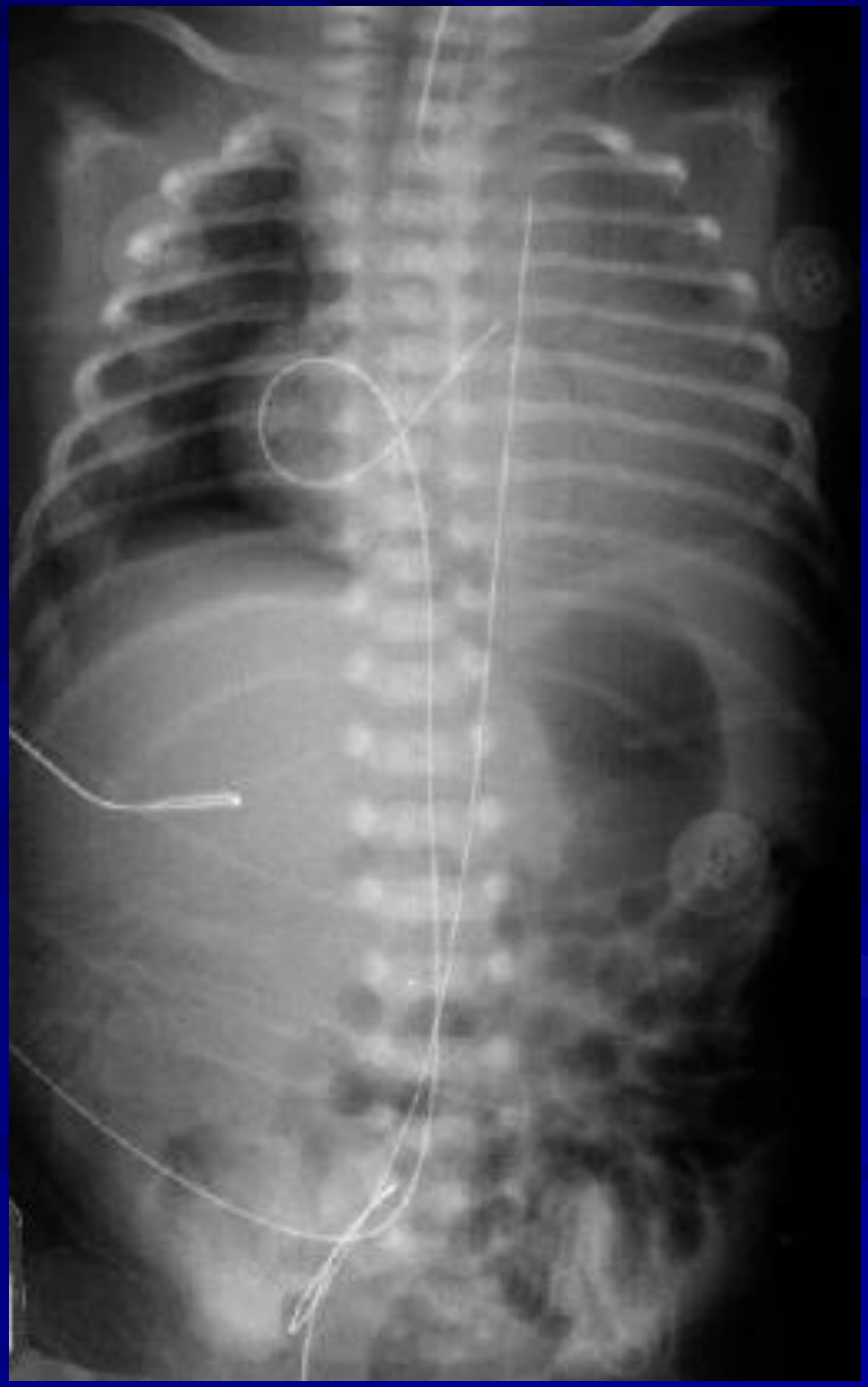


ETT in right mainstem.

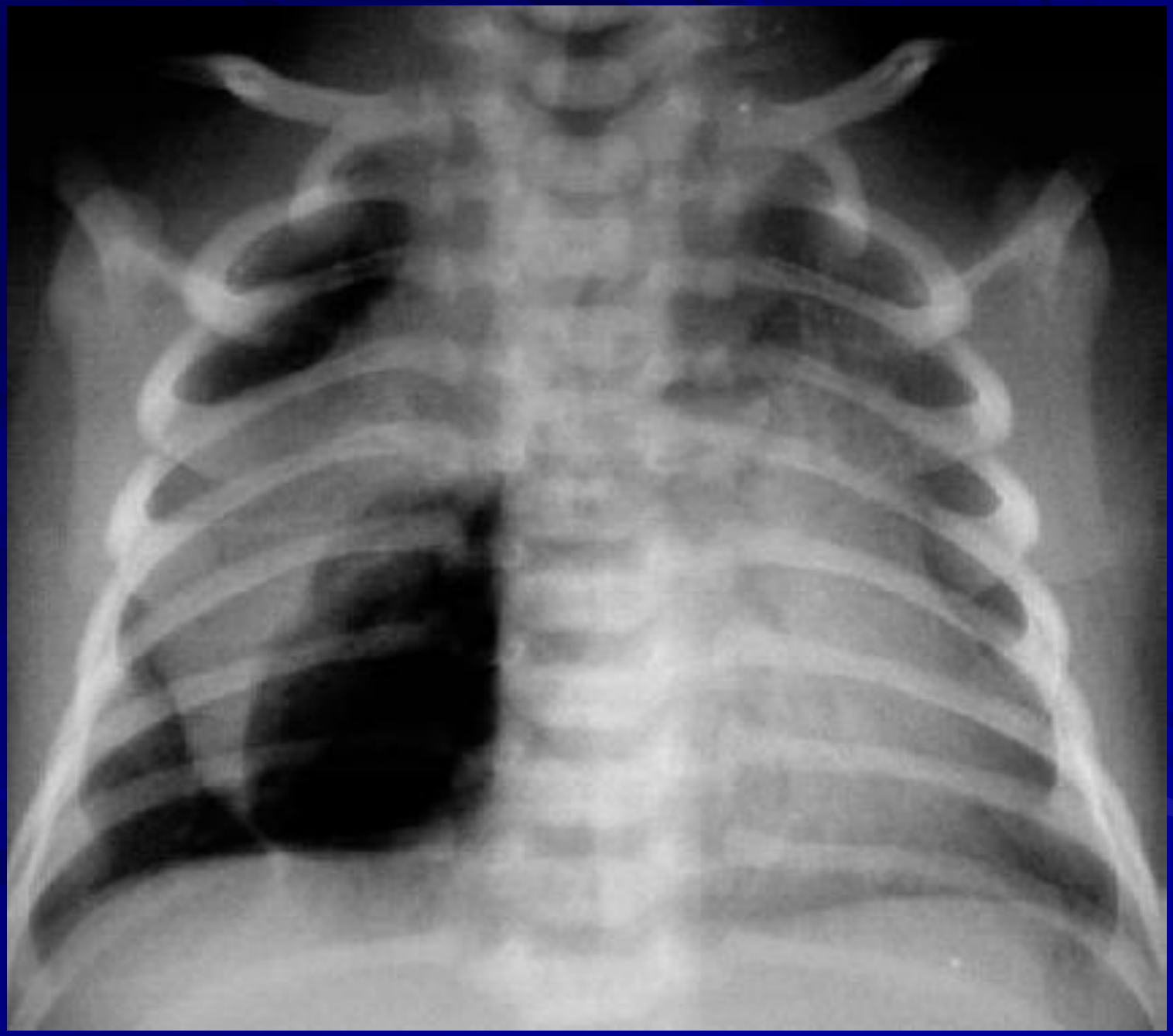
Too low. Reposition it.



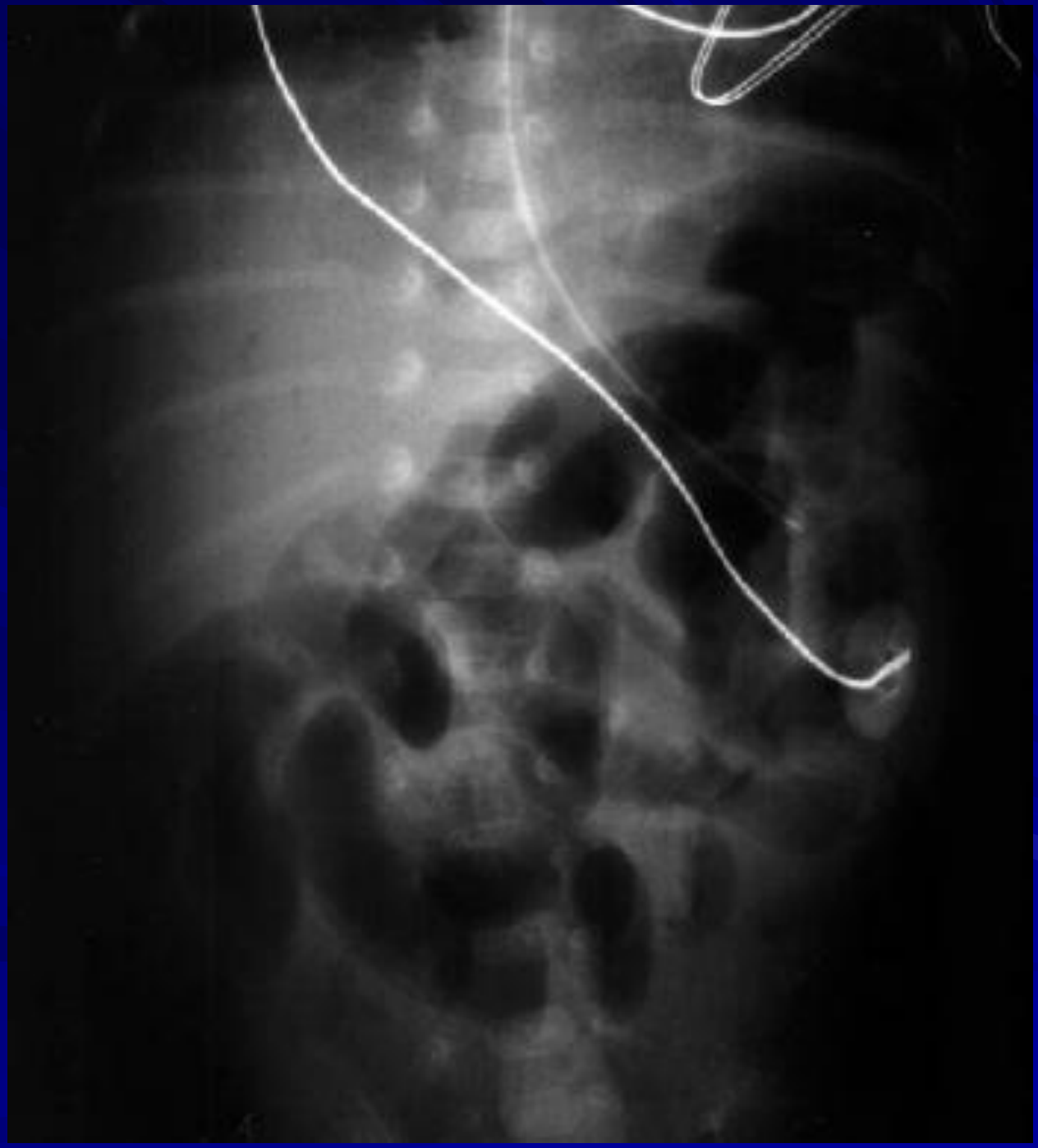
Pneumomediastinum. Note how the thymus is elevated (pushed up by mediastinal air), most visible on the right. There is also a small right pneumothorax.



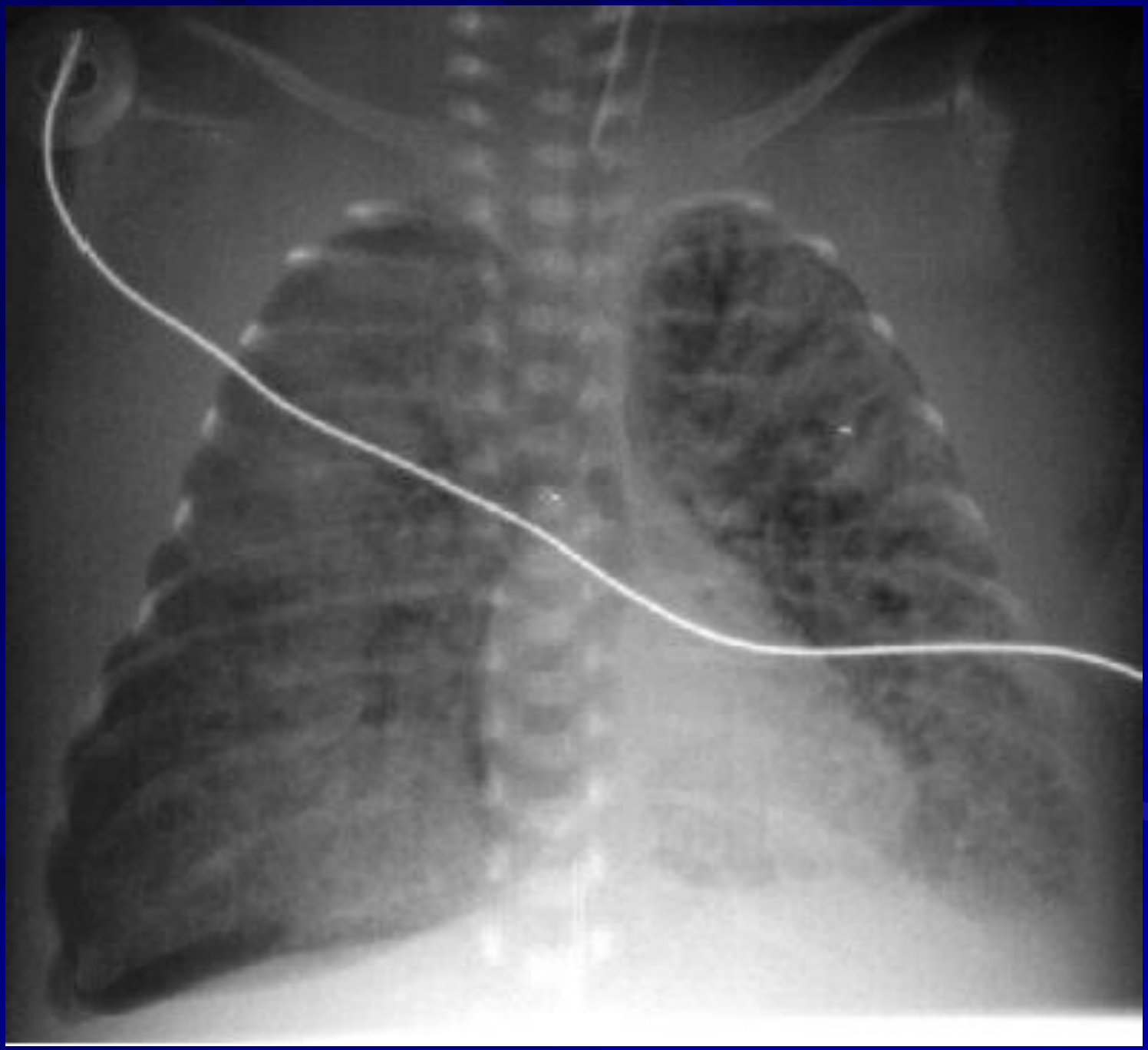
UVC looping in heart (up IVC and into RA). UAC at T2 (up aorta on left with the tip in the aortic arch). UVC and UAC are too high.



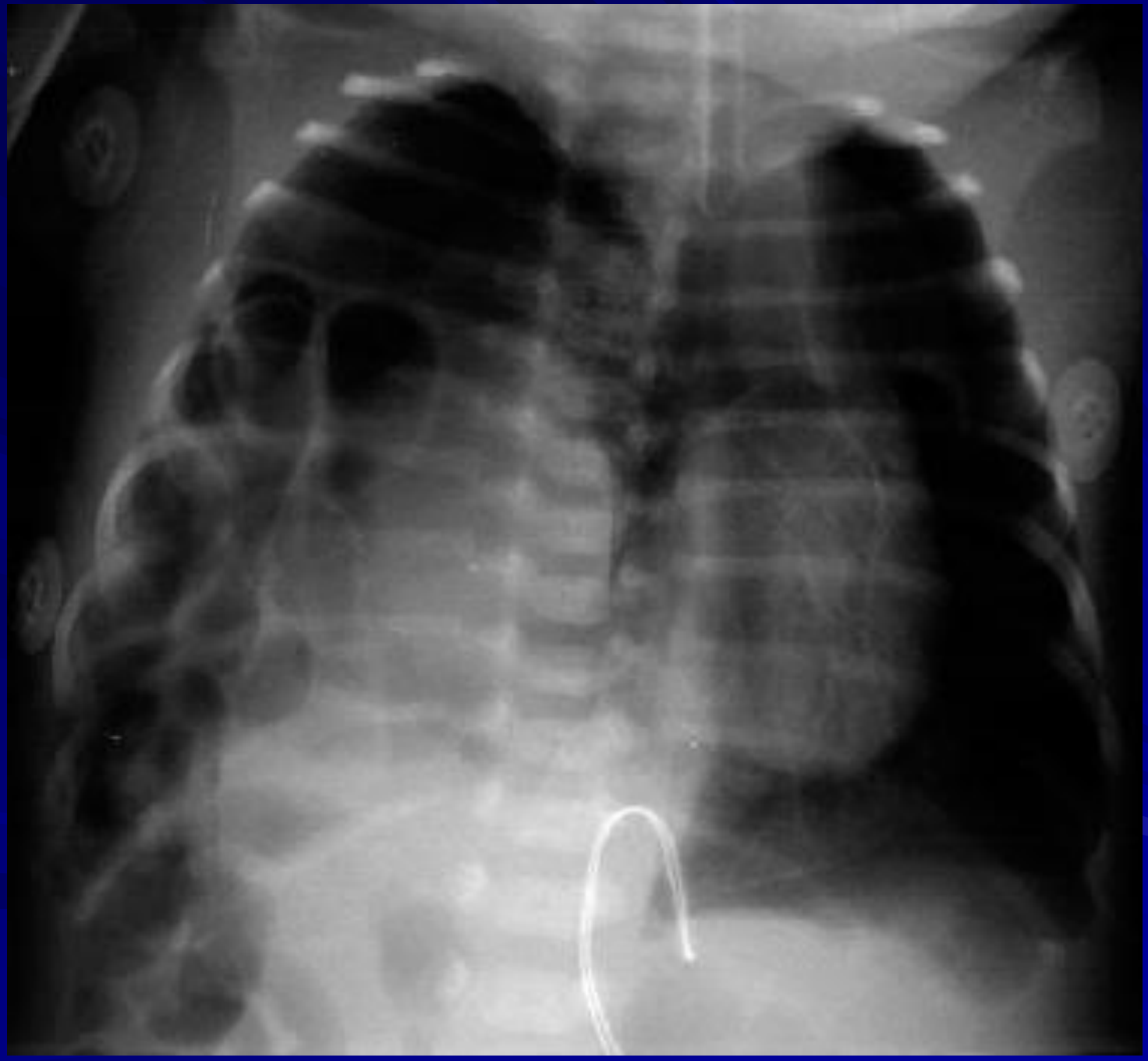
Right pneumothorax.



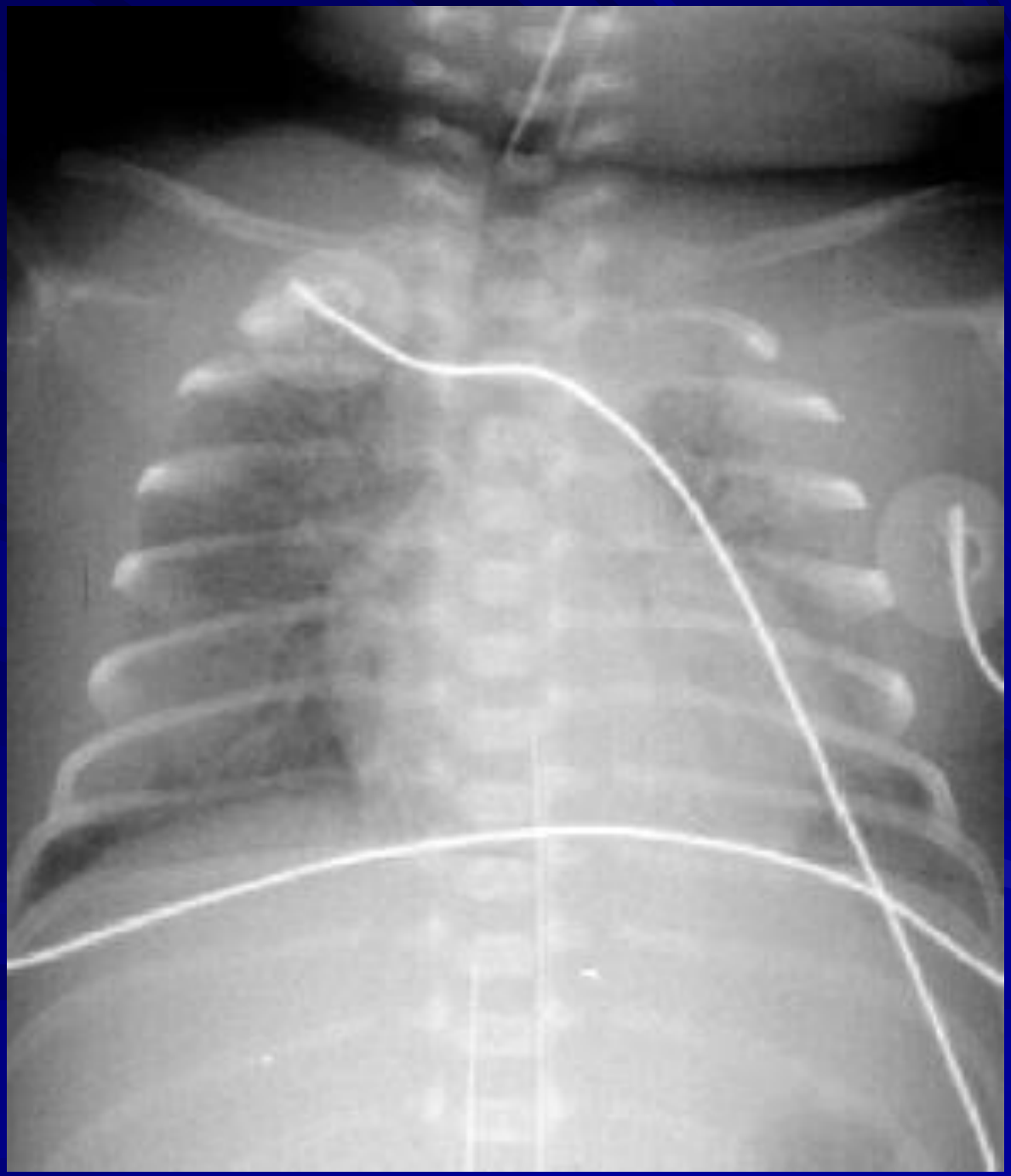
Pneumatosis intestinalis. Note the double linear density of the bowel wall indicative of air within the bowel wall (intramural air). There are also subtle air densities over the liver. This suggests that there is air in the portal circulation (intraportal air). Both findings indicate necrotizing enterocolitis.



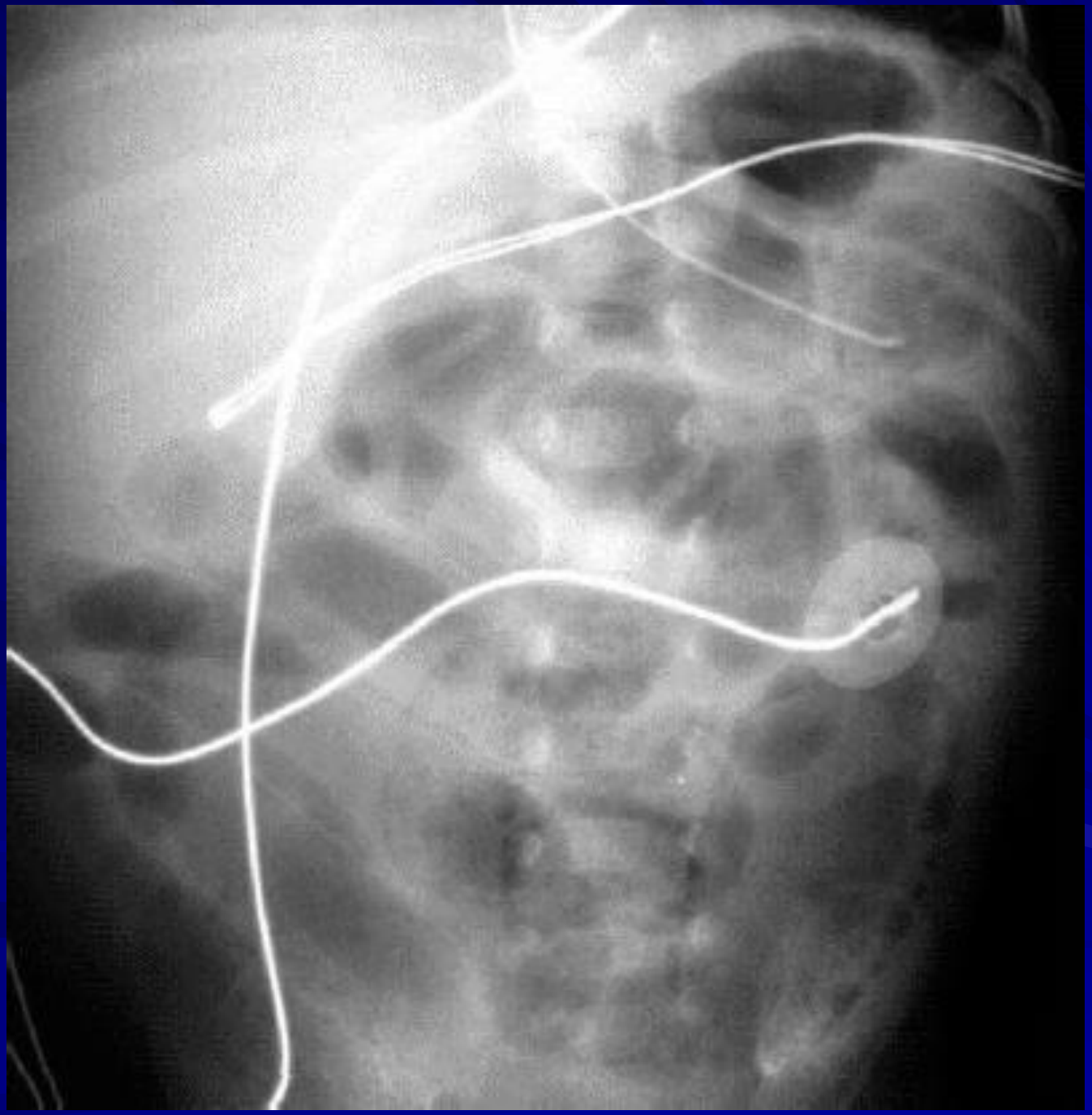
Pulmonary interstitial emphysema. ETT too high. UAC just above diaphragm.



Right diaphragmatic hernia and left pneumothorax.

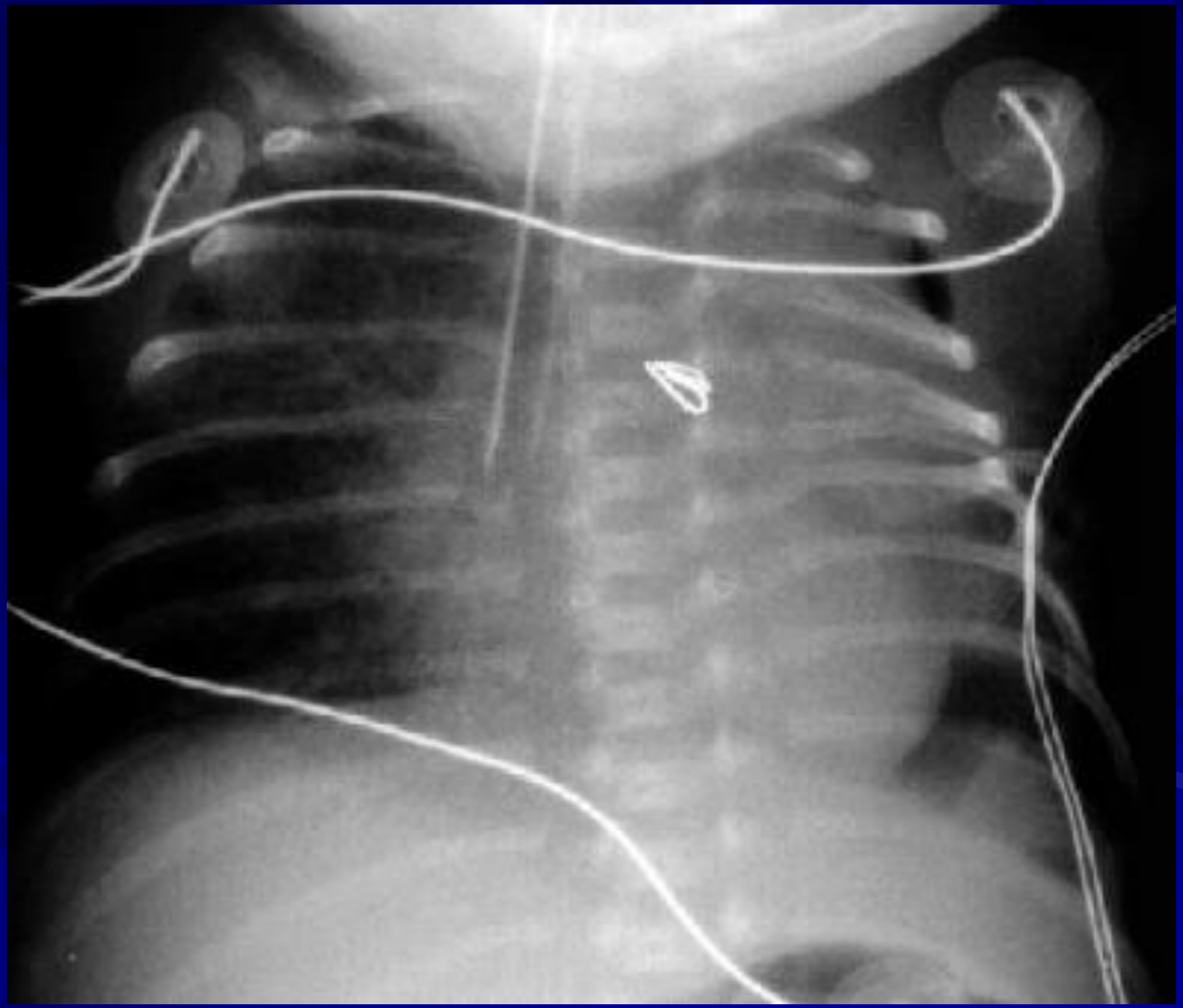


Respiratory distress syndrome. ETT too high. UVC in liver on right.



Pneumatosis intestinalis. Very obvious case. Tremendous amount of air in bowel walls.

Name three things wrong with this x-ray? 1) Severe pulmonary interstitial emphysema. 2) ETT too high. 3) UAC too low.



ETT too low. Left pneumothorax.

THANK YOU